



This is a digital copy of a book that was preserved for generations on library shelves before it was carefully scanned by Google as part of a project to make the world's books discoverable online.

It has survived long enough for the copyright to expire and the book to enter the public domain. A public domain book is one that was never subject to copyright or whose legal copyright term has expired. Whether a book is in the public domain may vary country to country. Public domain books are our gateways to the past, representing a wealth of history, culture and knowledge that's often difficult to discover.

Marks, notations and other marginalia present in the original volume will appear in this file - a reminder of this book's long journey from the publisher to a library and finally to you.

Usage guidelines

Google is proud to partner with libraries to digitize public domain materials and make them widely accessible. Public domain books belong to the public and we are merely their custodians. Nevertheless, this work is expensive, so in order to keep providing this resource, we have taken steps to prevent abuse by commercial parties, including placing technical restrictions on automated querying.

We also ask that you:

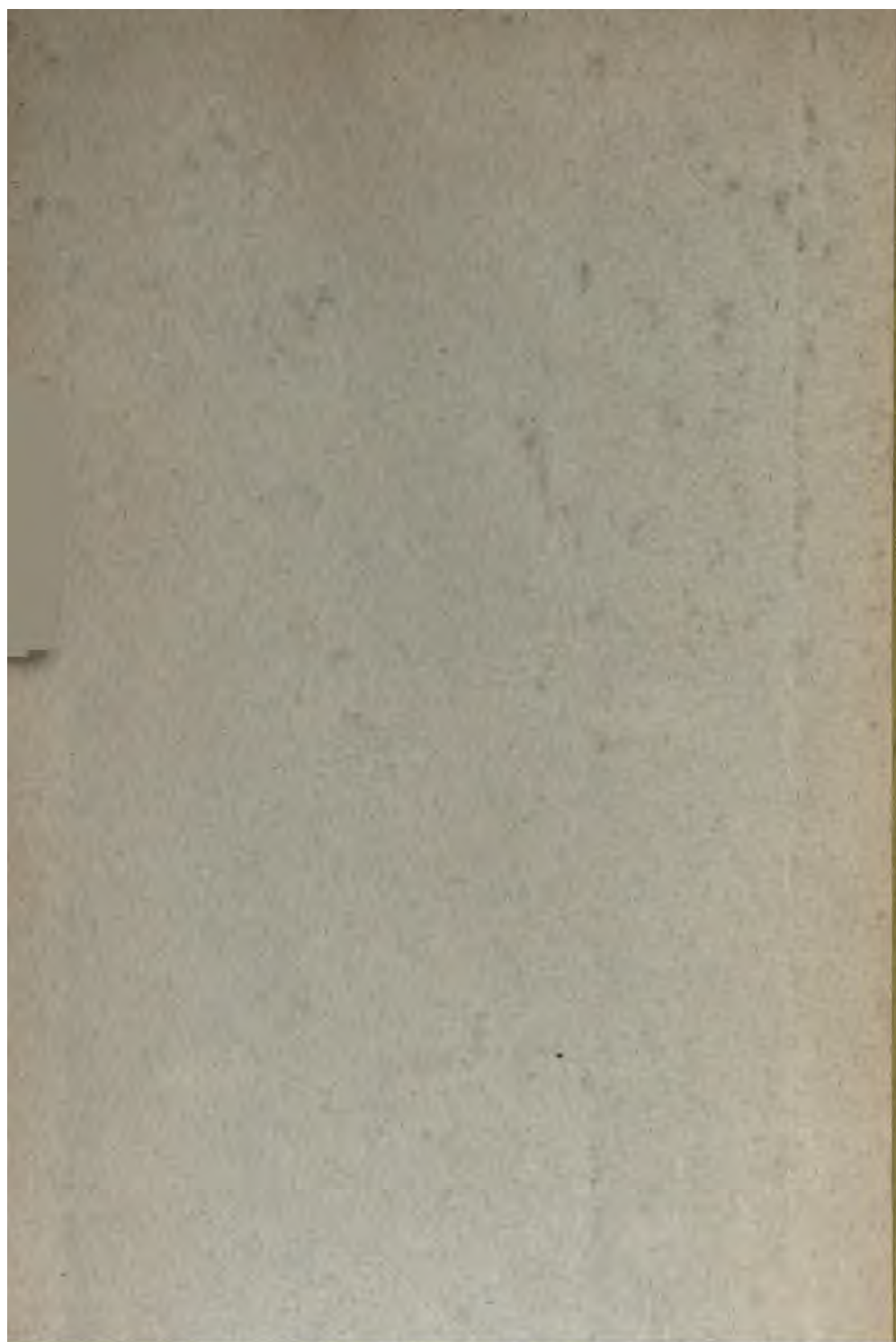
- + *Make non-commercial use of the files* We designed Google Book Search for use by individuals, and we request that you use these files for personal, non-commercial purposes.
- + *Refrain from automated querying* Do not send automated queries of any sort to Google's system: If you are conducting research on machine translation, optical character recognition or other areas where access to a large amount of text is helpful, please contact us. We encourage the use of public domain materials for these purposes and may be able to help.
- + *Maintain attribution* The Google "watermark" you see on each file is essential for informing people about this project and helping them find additional materials through Google Book Search. Please do not remove it.
- + *Keep it legal* Whatever your use, remember that you are responsible for ensuring that what you are doing is legal. Do not assume that just because we believe a book is in the public domain for users in the United States, that the work is also in the public domain for users in other countries. Whether a book is still in copyright varies from country to country, and we can't offer guidance on whether any specific use of any specific book is allowed. Please do not assume that a book's appearance in Google Book Search means it can be used in any manner anywhere in the world. Copyright infringement liability can be quite severe.

About Google Book Search

Google's mission is to organize the world's information and to make it universally accessible and useful. Google Book Search helps readers discover the world's books while helping authors and publishers reach new audiences. You can search through the full text of this book on the web at <http://books.google.com/>



3 3433 06275450 6





SEP 18 1909

T 22

★ CONNECTICUT SOCIETY
OF
CIVIL ENGINEERS



1906

W. H. ...

Genuine Rosendale Cement



Used in the construction of nearly all the
Yale Buildings, New Haven, Conn.

Over one hundred miles of sewers in New Haven
were built with Rosendale

ONE PROMINENT ARCHITECT WRITES

"I have uniformly specified and insisted on your Cement, sometimes when others would have been easier to get, and have found it superior for floor work to Portland"

CONSOLIDATED ROSENDALE CEMENT CO.

F. N. STRANAHAN, Sales Agent

26 Cortlandt Street

New York City

✓
Connecticut
Society of Civil Engineers



Papers and Transactions for 1906⁵

AND

Proceedings

OF THE

Twenty-Second Annual Meeting

AT

NEW HAVEN, FEBRUARY 13 AND 14, 1906



New Haven

THE TUTTLE, MOREHOUSE & TAYLOR COMPANY

1906



Connecticut Society of Civil Engineers

ORGANIZED AT BRIDGEPORT, JANUARY 15, 1884

Officers for 1906

CHARLES F. CHASE, NEW BRITAIN, ... *President*
D. S. BRINSMADE, DERBY, ... *First Vice President*
EDWARD W. BUSH, HARTFORD, ... *Second Vice President*
J. FREDERICK JACKSON, NEW HAVEN, ... *Secretary and Treasurer*

Directors

HENRY J. KELLOGG, NEW HAVEN.

EDWIN D. GRAVES, HARTFORD.

GEORGE K. CRANDALL, NEW LONDON.

JOHN K. PUNDERFORD, NEW HAVEN.

JOHN W. BUSH
CLARENCE
V. A. BUSH

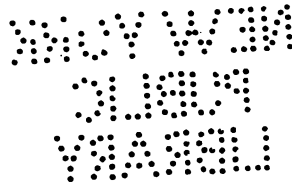
CONTENTS.

Sewage Disposal at Waterbury (R. A. Cairns).....	1
Discussion	49
The Kimberly Avenue Bridges of New Haven (Cassius W. Kelly)..	11
Discussion	58
A Spiral Curve for Street Railways (Albert M. Turner).....	17
Discussion	62
Ash Creek Bridge (Edward A. Minor).....	20
Discussion	64
Reinforced Concrete Tanks (Charles A. Ferry).....	26
Discussion	67
The Rebuilding of the Housatonic River Bridge (Alfred H. Terry)	33
Discussion	66
Street Scenes in Manila and Life in the Philippines (Desmond Fitzgerald)	42
PROCEEDINGS	
Report Board of Direction	75
" Treasurer	77
" Secretary	78
Address of President	81
Election of Officers	87
Summer Meeting	91
Constitution and By-Laws	93
List of Members	101

LIST OF EX-PRESIDENTS

WITH DATES OF SERVICE

B. HULL	1884, 1885
CHARLES M. JARVIS	1886
CHARLES E. CHANDLER	1887
CHARLES H. BUNCE	1888, 1889
F. FLOYD WELD	1890
E. P. AUGUR	1891, 1892, 1893, 1894
WM. G. SMITH	1895, 1896
ROBERT A. CAIRNS	1897, 1898
EDWIN D. GRAVES	1899, 1900
HENRY J. KELLOGG	1901
CLARENCE B. VORCE	1902
FREDERICK L. FORD	1903
JOHN K. PUNDERFORD	1904
ALBERT B. HILL	1905



SEWAGE DISPOSAL AT WATERBURY.

By R. A. Cairns, City Engineer.

Some other method of sewage disposal than discharge untreated into the Naugatuck river has been contemplated by the city of Waterbury for many years. A suit brought in 1891 was ultimately decided against the city. From time to time reports were prepared and submitted to the board of aldermen, containing suggestions and recommendations of experts, but up to date no final determination of the process to be used has been made.

The valley of the Naugatuck, in which Waterbury lies, is narrow and steep and is bounded on either side by rocky hills rising several hundred feet to the summits of the ranges. For twenty miles downstream there is no tract of land on the valley floor suitable for intermittent gravel filtration. The few level stretches are fully occupied by cities and villages, between which the valley is so narrow as scarcely to afford room for the highway and railroad.

There is one tract of land ten miles below the city, on a low plateau, which might possibly be utilized for filtration, and which could be reached by gravity. A careful study was made of it some years ago. It was found very expensive to develop, and the connection between it and the city was of necessity so located as to involve very expensive construction. Moreover development in the neighborhood has made such a use of the land of doubtful propriety, if indeed it would not be enjoined by the courts.

Testifying in a suit against the city, one of the best known sanitary engineers of the country stated that in his experience he had known of no other place where the difficulties of sewage disposal were greater than in the Naugatuck valley.

The flow of the river is not large enough to afford a degree of dilution sufficient to insure at all seasons against the creation of a nuisance. The distance to tide water is so great, over thirty miles, that the expense of a trunk sewer down the valley is and will long continue to be prohibitive. Moreover



MAIN SEWAGE CARRIER, WATERBURY, CONN.
REINFORCED CONCRETE.



MAIN CARRIER—INVERT COMPLETED.

the shellfish interests and owners of cottages along the sea-shore in the vicinity of the outlet would undoubtedly offer objections to such a disposition of the sewage.

Suitable land for filtration outside of the valley can only be reached by either pumping several miles over high hills, or by means of a long and expensive tunnel through the easterly range. The latter possibility, however, would have received particularly favorable attention had it not been that good ground exists for believing that manufacturing interests below Waterbury would seriously object to any reduction in the volume of water coming to them. This river flow is of the greatest importance to the brass mills, entirely aside from any use made of it for power, and they cannot contemplate with equanimity any reduction in it. On the contrary, they are actively concerned in its increase by means of storage reservoirs.

Chemical precipitation is not favorably considered, partly on account of the expense of the process, and particularly on account of the expense and difficulty attending upon the disposition of the sludge. Even after pressing, a large tract of low land is needed for its disposal.

Thus the field has narrowed down to some combination of sedimentation or septic tanks with modern bacteria beds, so-called, either contact or sprinkling.

It was not until 1904 that the problem of constructing sewage disposal works was committed to the engineering department of the city. Up to that time the matter had been handled by the legal department. Surveys were at once undertaken and prosecuted for a number of months, and after careful examination a route was selected for the main carrier, so-called, and a tract of land was decided upon as the only available place for disposal works. Construction of the main carrier is now under way; it consists of a reinforced concrete masonry channel, as shown in the photographs, $4\frac{1}{2}$ ft. wide and 4 ft. 5 in. high.

Some delay has been experienced in getting possession of the land needed for the works. Part of it has been bought and part is in process of being taken by condemnation proceedings. Through the tract runs the Naugatuck Division of the N. Y., N. H. & H. R. R. Co., cutting it fairly in two. As the present location of the road is on a big curve, the city succeeded in

inducing the company, in connection with its extensive improvements now making throughout the Naugatuck valley, to build a cut-off about two thirds of a mile long, shortening the road 680 feet, eliminating nearly all the curvature, and leaving our tract in one solid piece. It will be some time yet before the railroad will be able to complete this change, having some heavy rock cuts to make on it.

While waiting to get on this land we are building the sewer, as noted above, and are also taking advantage of the opportunity to make some careful studies in regard to the methods of treatment best adapted to our special conditions.

It is unnecessary for me, in speaking to this body of technical men, and at this late day, to justify the expenditure of a large amount of time and money in an experiment station for this purpose. After many costly failures in sewage disposal, it has finally been accepted by the profession as the only safe rule to be followed. In every community the elements of the problem vary, and in each the proper solution must be worked out for that special case.



SEWAGE EXPERIMENT STATION,
WATERBURY, CONN.

At the present moment Columbus, Ohio, where a staunch Connecticut man, Mr. Julian Griggs, is city engineer, is setting a good example in this respect. He secured the appropriation of \$50,000 to be expended in experiments on sewage purification. These were conducted under the direction of Messrs. Rudolph Hering and George W. Fuller of New York, and have attracted a great deal of attention for their extent and



DOUBLE CONE SPRINKLER.

thoroughness. They have been commented on at length in the engineering papers, and many of you are doubtless familiar with the interesting results obtained.

I submit herewith some drawings and photographs showing the general arrangements of our station and the appearance of the tanks. The sewage is pumped from one of the principal outfall sewers by means of a small centrifugal pump driven by a water motor. The discharge is about 46 gallons per minute. It enters a grit chamber and thence passes through screens and measuring orifices to three tanks having a capacity of 4000 gallons each. One of these is being used as a plain

sedimentation tank, with a period of 24 hours, and two are running as 16-hour septic tanks.

Below these are 6 circular tanks having each a surface area of 1-1000 acre. Sewage reaches them by gravity from the septic and sedimentation tanks through a system of piping admitting of various combinations of treatment. The overflow from the grit and screen chamber and the effluents from the tanks return to the sewer through drain pipes.

A one-story building 17 feet by 26 feet contains the pumping machinery, chemical mixing apparatus, etc. and the laboratory. The latter is quite well equipped for the purpose of sewage analysis.

The six circular tanks are arranged in sets of three, at different elevations. The first three are low enough so that sewage can be discharged near the top. They are now being used for standard sand filtration, at rates varying from 100,000 to 200,000 gallons per day per acre.

The filtering material is 5 feet in depth with an effective size of .24 mm. and a uniformity coefficient of 2.8.

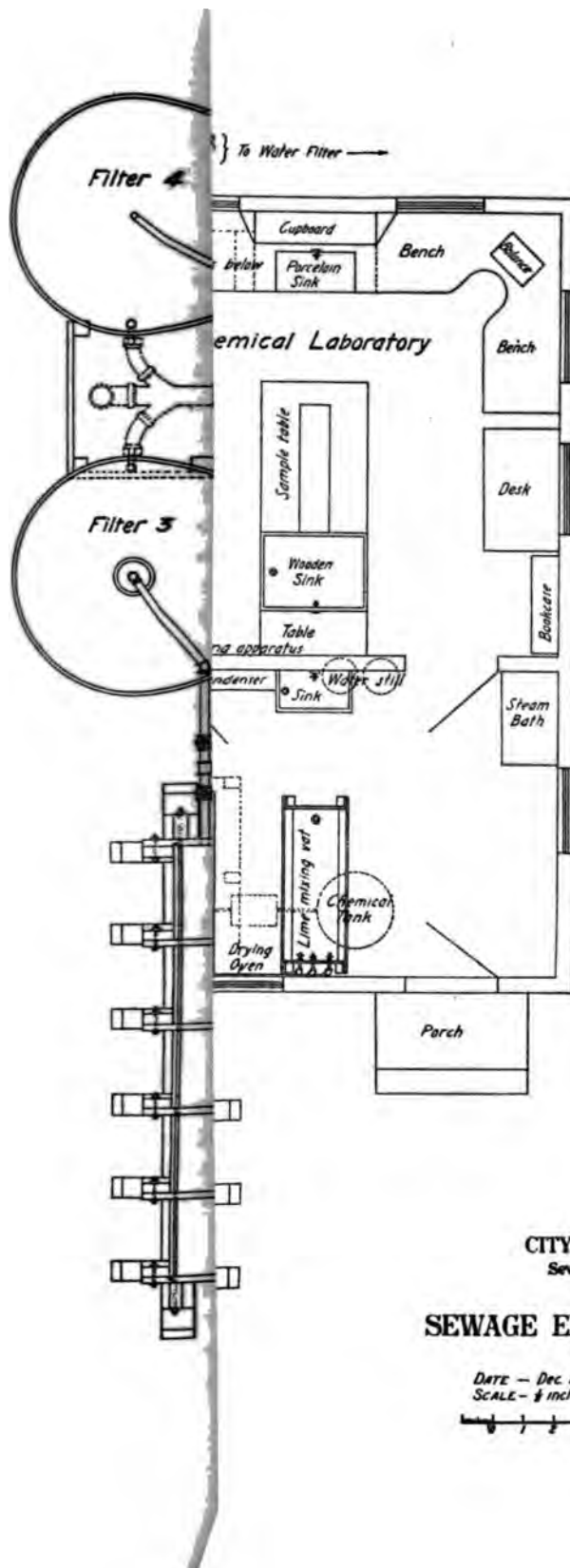
The second set of tanks stands low enough so that sewage from the sedimentation and septic tank level comes to them under several feet head, enough to permit of the operation of devices for sprinkling the sewage over the beds.

The principal object of the sand beds has been to see what degree of purification could be obtained by a well known standard process, thus discovering practically whether the sewage was of an exceptionally troublesome character. It is safe to conclude, from the results obtained by intermittent filtration, that the sewage of Waterbury at present does not contain such an amount of acids or metallic salts as to interfere with ordinary bacterial action.

Having determined this, it may be that one or more of this set of tanks will be converted into contact beds, and a series of experiments made along that line.

The lower set of tanks are all filled with 2-inch trap rock to a depth of 5 feet. A central standpipe brings up sewage from one of the sedimentation or septic tanks to a sprinkling device a couple of feet above the surface of the stone.

By this means the sewage is thrown out over the bed in an umbrella-shaped spray, falling on the stones in detached drops.



CITY OF WATERBURY
Sewage Disposal Works
PLAN OF
SEWAGE EXPERIMENT STATION

DATE — DEC. 14, 1902
SCALE — $\frac{1}{8}$ inch = 1 foot

ROBERT A. CAIRNS, C.E.
City Engineer
WM. SAVIN TAYLOR
Resident Engineer

This gives some aeration, an important step between the anaerobic processes of the septic tank and the aerobic action. In order to get a more even distribution, various forms of nozzle were tried. At present we are using one having two cones of different shape, one above the other. A hole through the lower cone allows the central portion of the stream to pass upward and impinge on the second cone. In this way we get two different zones of spray. By automatically varying the head and using these double nozzles, it is probable that a very satisfactory distribution may be obtained.

Before considering the results of the more rapid processes of sewage treatment, I want to call your attention to the fact that Waterbury conditions do not require an especially high degree of purification. The Naugatuck river can never be used as a source of pure water though every particle of city sewage were kept out of it. The only reasonable requirement that can be imposed is that our disposal works produce an effluent which will not be subject to putrefaction after discharge into the river. The court order under which we are proceeding only requires treatment during the six months between May 1st and December 1st. The remainder of the year we may discharge crude sewage directly into the river as heretofore.

Under these conditions our endeavor is to find that method of treatment which will handle the greatest quantity of sewage at the least expense, counting first cost and operation, using the smallest area, and producing a nonputrescible effluent.

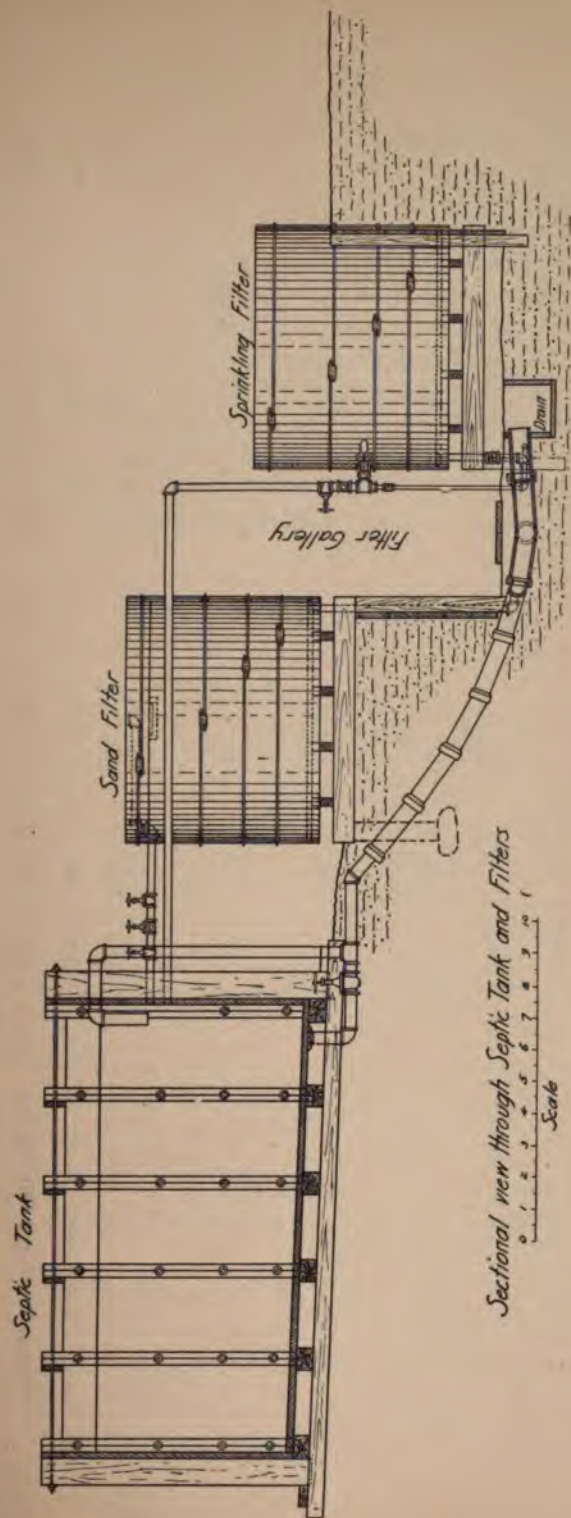
To determine this last point samples of effluents are placed in an incubator at a temperature of 100° F. and kept there for 24 hours. If no fermentation results the effluent is considered satisfactory. River water in shallows is not likely at any time to reach a temperature of much over 80°. Formerly a lower temperature, 70° to 80°, was used in the incubator and samples kept a longer time. But experiments have shown that the higher temperature and shorter time give equally reliable results and of course permit more tests to be made with a given equipment.

I submit herewith three samples of effluents taken from our experiment station. One is from the sand filter, working at a rate of 200,000 gallons per day per acre, and with a rest of one whole day in seven.

PURIFICATION EFFECTED BY TREATMENTS.
MONTHLY AVERAGE, DECEMBER, 1905.

DEVICES.	TOTAL ORGANIC NITROGEN.				OXYGEN CONSUMED.				TOTAL SUSPENDED MATTER.				VOLATILE SUSPENDED MATTER.			
	Crude Sewage.	Eff.	Per cent. reduction.	Crude Sewage.	Eff.	Per cent. reduction.	Crude Sewage.	Per cent. reduction.	Crude Sewage.	Eff.	Per cent. reduction.	Crude Sewage.	Eff.	Per cent. reduction.	Crude Sewage.	Per cent. reduction.
Septic Tanks.....	11.0	5.7	47	53	37	30	128	59	53	113	53	53				
Settling Tank		7.4	33	....	40	25	...	68	47	....	59	48				
Settling Tank and Filter <u>21</u>		1.3	88	....	6.8	87										
Septic Tank II and Filter <u>22</u>		1.2	89	....	6.5	88										
Septic Tank III and Filter <u>23</u> ...		1.9	83	....	7.6	86										
Septic Tank III and Filter <u>24</u>		3.2	71	....	23	57	....	33	74	....	30	73				
Septic Tank II and Filter <u>25</u>		3.7	66	....	22	59	....	38	70	....	34	70				
Settling Tank and Filter <u>26</u>		3.1	72	....	23	57	....	34	73	....	30	73				

Parts per million.



Sectional view through Septic Tank and Filters

The other two are from the sprinkling filters, working at rates of 2.7 and 2.5 million gallons per day per acre, with a rest of one day in seven. These have all been incubated as described, and have given no evidence of putrescence.

Our experimental work has only gotten fairly started, so that I am not prepared to make any positive statements of results. As a matter of interest, however, I append a table of averages obtained by the chemist during the month of December last. A year from now I hope that we will have demonstrated some things in connection with sewage disposal which will be of advantage both to Waterbury and to other industrial communities so similarly situated as to be unable to practice sewage purification by intermittent filtration through gravel and sand.

1000

THE KIMBERLY AVENUE BRIDGES OF NEW HAVEN.

By Cassius W. Kelly, City Engineer.

Kimberly Avenue in New Haven crosses West River and the meadows or mud flats in a southwesterly direction from New Haven to West Haven. The river crosses this street in two branches about eight hundred feet apart. Over the southerly or main branch is being constructed an open bridge of the type known as a Scherzer Rolling Lift Bridge. Over the northerly channel a smaller fixed bridge of concrete, in part reinforced, and steel I beams, is being constructed.

These bridges replace old pile and timber structures. The mud at the site of the two bridges and over the intervening distance is from twenty-nine to thirty-four feet in depth below mean low water. Over the site of the lift bridge there is a hard crust from two to eight feet thick and at a depth to the upper surface of nineteen to twenty-five feet below mean low water. Much of this crust was found in driving the piles to be very hard and nearly as hard as anything encountered in the hard bottom below the mud. The bridge over the main branch of the river consists of two approach spans and the lift span in the middle. The bridge has a total length of 196 feet and a roadway width of forty-four feet and total width of sixty-six feet.

The opening of the middle span is forty-five feet in the clear at right angle with the direction of the current. The abutments and piers are built parallel with the direction of the current and form an angle of 60° with the bridge. The general location plan is shown on plate 1.

The lift span is in two leaves and opens square with the piers.

The substructure masonry is of concrete. The concrete of the piers is carried to a depth of twelve feet below mean low water and is supported on a timber platform twenty-eight

inches in thickness, resting on piles. The details of the piers in plan and section will be seen by reference to plate 2. The con-

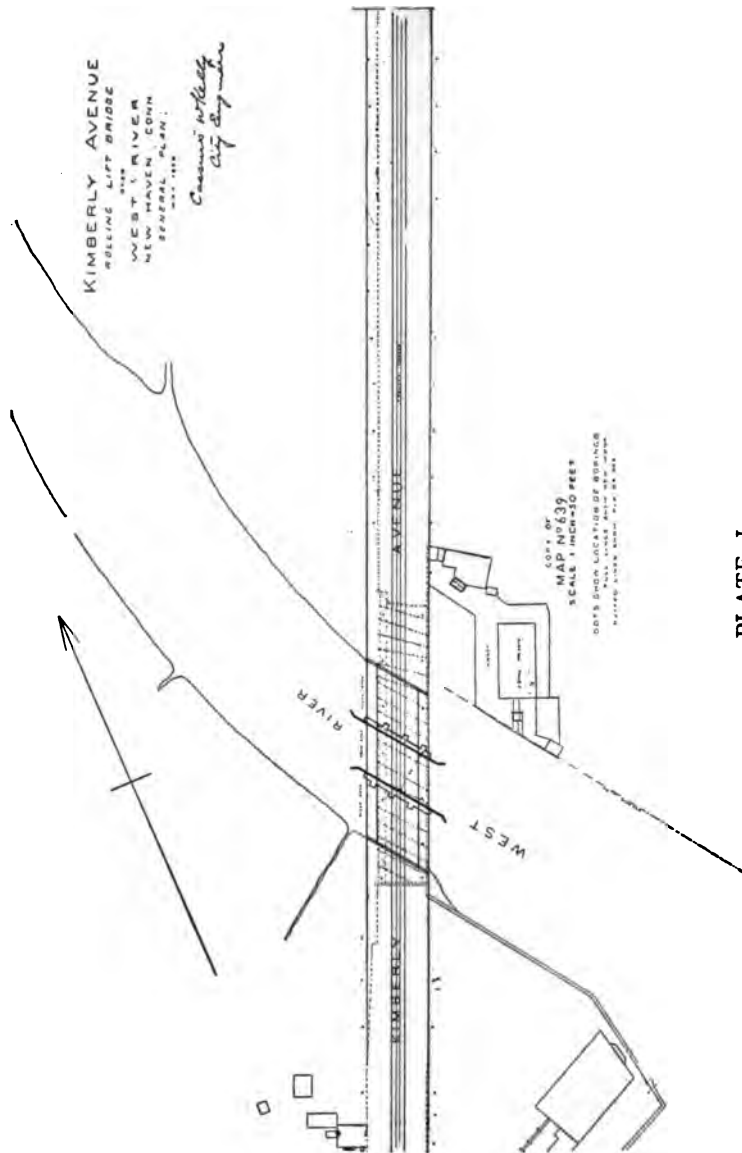


PLATE I.

crete of the abutments and retaining walls is placed upon and about the piles, which are cut off a little above low water.

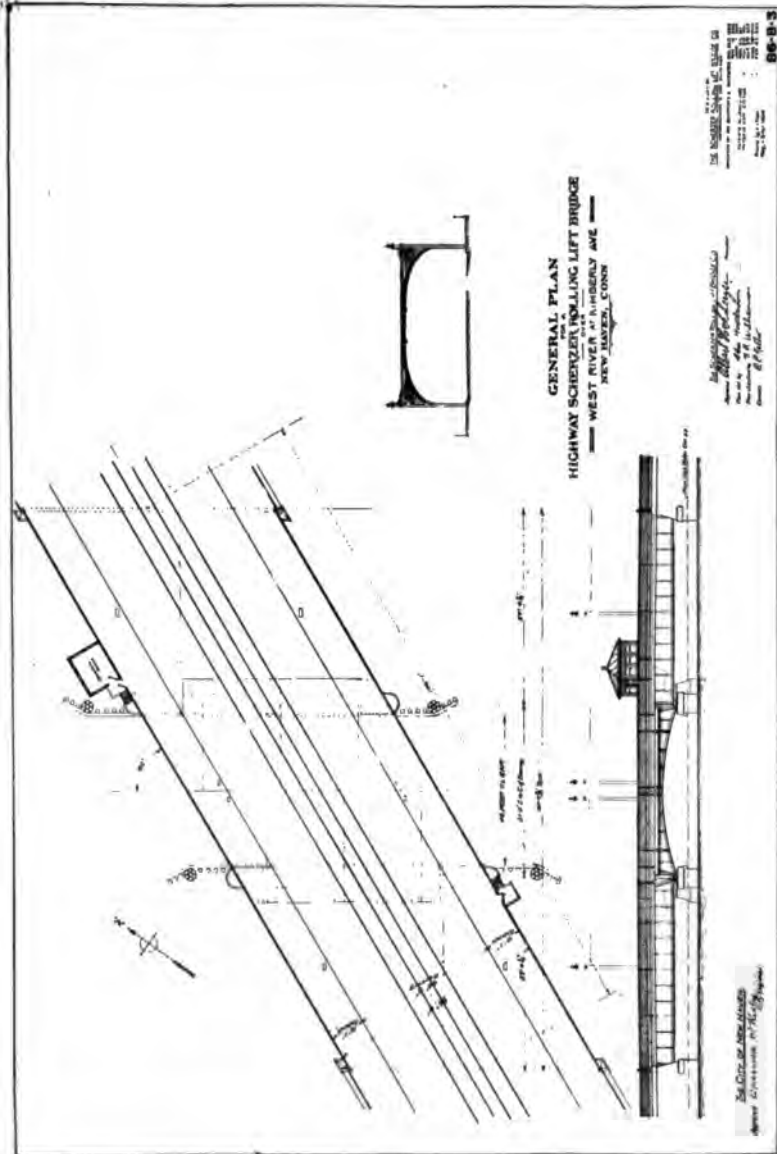
The piers were built by means of open caissons. Before driving the piles for the foundation of the piers, the mud was dredged out to a depth of three or four feet below the level of the cut-off of the piles, and after the piles were cut off, rip-rap of small size was deposited about the piles and allowed to crown about one inch above the piles. Each pile head, in regular order, was examined by a diver to see that the piles were free from stones. This rip-rap is near to and in some portions nearly in contact with the hard crust.

The caissons were eighty-nine feet long and seventeen feet wide and were placed in position without mishap. The piers were built solid from end to end up to low water, and from that point were carried up in three pedestals. The forms for the concrete were made of inch boards, matched and planed, except for the backs of abutments and retaining walls, which were of rough stuff. The work was started with the use of two-inch plank, but it was found that the plank, which were not always, nor generally, true, could not, when of that thickness, be sprung vertically so as to secure tight joints throughout. As the forms could not be removed while the work was comparatively green, except in the case of the retaining walls, it was essential to have tight joints to secure smooth surfaces. These forms were brushed on the inside with soft soap before placing the concrete.

The concrete was made with Portland cement mixed in the proportion of 1, 3, 6 for the retaining walls, and 1, 2, 5 for the abutments and for the piers up to low water; and one man stone was distributed throughout, spaced, about six inches apart. The pedestals of the piers are 1, 2, 4 mixture and without the one man stone. The outer face of all work for a thickness of four inches is a mixture of 1, 2, 2, no stone exceeding one inch in largest dimension and for the most part not exceeding three-fourths of an inch. This thickness of four inches for the facing was easily regulated by placing a row of one man stone on each successive layer of concrete about four inches from the face. The southerly abutment and a portion of the southerly pier was brushed over with a thin mixture of one of Portland cement to one of sand, but the rest of the work was left as it came from the forms.

The general design of the superstructure is shown in plate 3.

PLATE III.



Each lift will be operated by means of an electric motor of street car type, geared to a shaft passing through the center of

the outer rocking girders. A pinion attached to the outer ends of the shaft engages in a horizontal rack which is attached to a frame anchored to, and in part imbedded in, the concrete pier. The details of rocking girders, rack, track, etc. are shown on plate 4.

The flooring is of creosoted plank upon which is laid a pavement of creosote-resinate wood blocks. To insure the holding of the blocks on the lift span the roadway is crossed at intervals of eight feet with $2\frac{1}{2} \times 2\frac{1}{2} \times \frac{1}{4}$ inch angles spiked to the planking and, in addition, the blocks will be imbedded in a thin coat of asphaltic cement spread over the roofing felt, which will be firmly tacked to the planking.

The plans for the superstructure were prepared by the Scherzer Rolling Lift Bridge Co. as consulting engineers and the plans for the substructure were prepared in the office of the city engineer.

The northerly bridge referred to above, the plans for which were also prepared in the office of the city engineer, has a total length of seventy-five feet and a width of sixty-seven feet and is divided into three spans by reinforced concrete pier columns carrying reinforced concrete beams. These pier columns have the bases spread and rest in each case upon a cluster of seven piles. The full size of the base is kept down to low water, by requirement of the War Department. The three columns in the central portion of each beam and which carry the trolley tracks, being nearer together than the others, have their bases continuous. The concrete in the abutments and retaining walls was mixed in the proportion of 1, 3, 6 except the facing, which is a 1, 2, 2 mixture and have one man stone distributed throughout, spaced four inches apart. The concrete in the columns and beams and flooring is a mixture of 1, 2, 4. Upon the abutments and beams are placed I beam stringers spaced five feet apart and upon these I beams a reinforced concrete floor six inches in thickness. For the bottom transverse reinforcement of the floor, Kahn bars will be used, and for the longitudinal distributors and the top transverse reinforcement, twisted bars will be used. Upon this concrete floor will be laid a vitrified brick pavement. The sidewalks and railing will be of reinforced concrete. All exposed concrete surfaces of this bridge were hand-floated with a thin mixture of one Portland cement to one of sand.

A SPIRAL CURVE FOR STREET RAILWAYS.

By Albert M. Turner.

The spiral curve is so common as a headline in engineering periodicals that we sometimes underestimate the astonishing frequency with which the long-suffering public is up against the circular variety in the track. On the few steam railroads in our State which do not use some form of spiral curve, the passenger usually has a whole seat to himself and has become more or less inured and adapted to either end of the same, but when he dangles from a strap in a prancing trolley car the situation is somewhat different. This, of course, is no argument, but when we consider that the initial shock of a circular curve may very likely be beneficial to the passenger, and indeed give him more for his money, but is certainly of doubtful value to the rolling stock, then indeed the situation is radically different. To remedy this crying evil many and various systems of spirals have been proposed and used. They are all good, but there are certain features or characteristics which they do not all possess in like measure. For instance, having a given radius and angle of intersection, the tangent distance from P. I. to P. C., and the external distance from P. I. to the center of the curve, should be attainable by simple calculations, as these distances usually have to be determined in the King's highway, where truth is seldom stranger than fiction, but more difficult to identify. The spiral curve should be readily run by the transit, either forward or backward, and the figuring of deflections in the field should be avoided as far as possible. The number of chords in the spiral should be small, and the chord length should bear a simple ratio to the unit of 100 feet to facilitate the calculation of grades. Lastly, the curve should be pleasing to the eye of the engineer, soothing to the nerves of the nickel producer, and unnoticeable to the much more delicate rolling stock.

In the system herewith presented, the spiral curve always consists of four circular arcs whose radii, taken with the radius R of the circular central part of the curve form approximately the ascending series $R, \frac{5R}{4}, \frac{5R}{3}, \frac{5R}{2}, 5R$. Representing the deflection for a chord C on the circular part of the curve by D , the central angle subtended by that chord will be $2D$, and by the four spiral chords respectively, $\frac{8D}{5}, \frac{6D}{5}, \frac{4D}{5}, \frac{2D}{5}$, or, to present the relation more clearly, the whole series will be $5\left(\frac{2D}{5}\right), 4\left(\frac{2D}{5}\right), 3\left(\frac{2D}{5}\right), 2\left(\frac{2D}{5}\right), 1\left(\frac{2D}{5}\right)$. Summing up the central angles of the four chords, we have the constant relation, spiral angle $S = 4D$. Three functions remain to be determined, the lateral offset, or inthrow, P , the displacement or setback of the tangent point, Q , and the deflection angles. In compiling the tables of these functions, twenty-four representative curves were selected, with radii varying from 40 ft. to 2000 ft. and their functions laboriously dug up by the aid of a little geometry and much graphite. From the consideration of these data it soon became evident that the function P was in all cases represented by the simple expression $\frac{C^2}{R}$. The equivalent expression for Q was not so readily obtained, and is not so self-evident, but the expression $C\left(2 - 52 \sin^2\left(\frac{D}{5}\right)\right)$ was finally arrived at, and actually fitted the twenty-four curves already determined. By dividing all the deflection angles by D , the simple ratios given in the general table appeared, and it only remained to tabulate enough curves to cover ordinary practice. The expressions for tangent distance, T , external distance, E , and length of curve, L , in terms of the tabulated functions, follow readily from the figure, and present no serious obstacle to calculation, using either natural or logarithmic functions.

In field work the spirals are usually run in from the P. C. and P. T. respectively, then the transit set over either P. S., the total deflection checked, if possible, by a sight on the other P. S. and the circular curve "pulled in."

DEFLECTIONS CHORDS			
	30°	40°	50°
2	4864.9	2148.8	1219.1
7	2772.5	2096.4	1685.4
5	2685.9	2046.5	1653.0
8	2604.5	1998.9	1621.8
1	2527.9	1953.5	1591.8
9	2453.7	1910.1	1562.9
6	2387.5	1868.6	1535.0
2	2328.0	1828.8	1508.1
5	2261.9	1790.7	1482.1
7	2202.9	1754.2	1457.0

CHORDS				
	D	R	P	Q
12	42	429.78	1.48	49.96
42	42	421.35	1.48	49.75
54	42	418.25	1.51	49.95
46	42	405.46	1.54	49.95
48	42	397.95	1.57	49.95
10	50	390.72	1.60	49.95
52	50	383.75	1.63	49.94
54	50	377.01	1.66	49.94
56	50	370.52	1.69	49.94
58	50	364.24	1.72	49.94
20	0	358.17	1.75	49.94
22	0	352.20	1.77	49.93
24	0	346.32	1.80	49.93
26	0	340.52	1.83	49.93
28	0	335.80	1.86	49.93
20	10	330.63	1.89	49.93
22	10	325.62	1.92	49.92
24	10	320.77	1.95	49.92
26	10	316.05	1.98	49.92
28	10	311.47	2.01	49.92
20	20	307.03	2.03	49.91
22	20	302.70	2.06	49.91
24	20	298.50	2.09	49.91
26	20	294.42	2.12	49.91
28	20	290.44	2.15	49.90
20	30	286.57	2.18	49.90
22	30	282.80	2.21	49.90
24	30	279.12	2.24	49.90
26	30	275.56	2.27	49.89
28	30	272.07	2.30	49.89
20	40	268.67	2.33	49.89
22	40	265.37	2.36	49.88
24	40	262.12	2.39	49.88
26	40	258.97	2.41	49.88
28	40	255.89	2.44	49.88
20	50	252.88	2.47	49.87
22	50	249.94	2.50	49.87
24	50	247.07	2.53	49.87
26	50	244.26	2.56	49.86
28	50	241.52	2.59	49.86
20	60	238.84	2.62	49.86

12 INTERSECTION
 12 RADIUS OF C
 12 CHORD LENG
 12 DEFLECTION
 12 SPIRAL ANG
 12 BACK DEFLECT
 12 LENGTH OF C
 $P = \frac{C^2}{R}$
 $Q = C(2 - \frac{P}{R})$
 $T = (R + F)$
 $E = (R + F)$
 $L = C(\frac{2E}{R})$
 $\sin D = \frac{C}{2R}$

DEFLEC	
P.C.	I
TRANSIT	$\frac{1}{3} D$
$\frac{1}{3} D$	TRANSIT
$\frac{7}{10} D$	$\frac{2}{3} D$
$\frac{20}{15} D$	$\frac{11}{10} D$
$\frac{5}{2} D$	$\frac{31}{15} D$

f. w

OFFSETS O.I.P

DEFLEC

P.C. I

TRANSIT $\frac{1}{5} D$

$\frac{1}{10} D$ TRANSIT

$\frac{2}{10} D$ $\frac{2}{5} D$

$\frac{3}{10} D$ $\frac{3}{10} D$

$\frac{4}{10} D$ $\frac{4}{10} D$

$\frac{5}{10} D$ $\frac{5}{10} D$

$\frac{6}{10} D$ $\frac{6}{10} D$

$\frac{7}{10} D$ $\frac{7}{10} D$

$\frac{8}{10} D$ $\frac{8}{10} D$

$\frac{9}{10} D$ $\frac{9}{10} D$

$\frac{10}{10} D$ $\frac{10}{10} D$

$\frac{11}{10} D$ $\frac{11}{10} D$

$\frac{12}{10} D$ $\frac{12}{10} D$

$\frac{13}{10} D$ $\frac{13}{10} D$

$\frac{14}{10} D$ $\frac{14}{10} D$

$\frac{15}{10} D$ $\frac{15}{10} D$

$\frac{16}{10} D$ $\frac{16}{10} D$

$\frac{17}{10} D$ $\frac{17}{10} D$

$\frac{18}{10} D$ $\frac{18}{10} D$

$\frac{19}{10} D$ $\frac{19}{10} D$

$\frac{20}{10} D$ $\frac{20}{10} D$

12.5' CHORDS					12.5' CHORDS				
D	R	P	Q		D	R	P	Q	
10-0	358.12	0.44	24.99		30-20	107.47	1.43	24.91	
2	346.57	0.45	24.99		35	106.37	1.48	24.91	
4	335.74	0.47	24.99		40	105.38	1.52	24.90	
6	325.58	0.48	24.99		45	104.40	1.56	24.90	
8	315.99	0.50	24.99		50	103.43	1.60	24.89	
10-10	306.96	0.51	24.99		55	102.48	1.64	24.89	
12	298.44	0.52	24.99		60	101.54	1.67	24.88	
14	290.37	0.54	24.99		65	100.61	1.71	24.87	
16	282.73	0.55	24.99		70	99.69	1.75	24.86	
18	275.48	0.57	24.99		75	98.78	1.78	24.85	
20-20	268.60	0.58	24.97		80	97.88	1.82	24.84	
22	262.03	0.59	24.99		85	96.98	1.85	24.83	
24	255.81	0.61	24.98		90	96.09	1.89	24.82	
26	249.86	0.62	24.98		95	95.20	1.92	24.81	
28	244.18	0.64	24.98		100	94.32	1.96	24.80	
30-30	238.76	0.65	24.98		105	93.44	2.00	24.79	
32	233.57	0.67	24.98		110	92.57	2.04	24.78	
34	228.60	0.68	24.98		115	91.70	2.07	24.77	
36	223.84	0.70	24.98		120	90.84	2.11	24.76	
38	219.27	0.71	24.98		125	90.00	2.14	24.75	
40-40	214.89	0.72	24.98		130	89.16	2.18	24.74	
42	210.67	0.74	24.98		135	88.33	2.22	24.73	
44	206.63	0.76	24.98		140	87.50	2.25	24.72	
46	202.72	0.77	24.97		145	86.68	2.28	24.71	
48	198.98	0.79	24.97		150	85.86	2.32	24.70	
50-50	195.36	0.80	24.97		155	85.05	2.35	24.69	
52	191.87	0.81	24.97		160	84.24	2.39	24.68	
54	188.51	0.82	24.97		165	83.44	2.42	24.67	
56	185.26	0.84	24.97		170	82.64	2.46	24.66	
58	182.12	0.85	24.97		175	81.84	2.49	24.65	
60-60	179.09	0.87	24.97		180	81.05	2.53	24.64	
62	176.15	0.89	24.97		185	80.26	2.56	24.63	
64	173.31	0.90	24.97		190	79.47	2.60	24.62	
66	170.56	0.92	24.96		195	78.69	2.63	24.61	
68	167.90	0.93	24.96		200	77.91	2.67	24.60	
70-70	165.32	0.95	24.96		205	77.14	2.70	24.59	
72	162.81	0.96	24.96		210	76.37	2.74	24.58	
74	160.38	0.98	24.96		215	75.60	2.77	24.57	
76	158.02	0.99	24.96		220	74.83	2.81	24.56	
78	155.74	1.01	24.96		225	74.07	2.84	24.55	
80-80	153.51	1.02	24.96		230	73.31	2.88	24.54	
82	151.25	1.03	24.95		235	72.56	2.91	24.53	
84	149.05	1.05	24.95		240	71.81	2.95	24.52	
86	147.21	1.06	24.95		245	71.06	2.98	24.51	
88	145.22	1.08	24.95		250	70.32	3.02	24.50	
90-90	143.28	1.09	24.95		255	69.57	3.05	24.49	
92	141.40	1.10	24.95		260	68.83	3.09	24.48	
94	139.56	1.12	24.95		265	68.09	3.12	24.47	
96	137.78	1.13	24.94		270	67.35	3.16	24.46	
98	136.03	1.15	24.94		275	66.62	3.19	24.45	
100-100	134.24	1.16	24.94		280	65.89	3.23	24.44	
102	132.60	1.18	24.94		285	65.16	3.26	24.43	
104	131.06	1.19	24.94		290	64.43	3.30	24.42	
106	129.43	1.21	24.94		295	63.70	3.34	24.41	
108	127.94	1.22	24.94		300	62.98	3.37	24.40	
110-110	126.44	1.24	24.94		305	62.25	3.41	24.39	
112	124.97	1.25	24.93		310	61.53	3.44	24.38	
114	123.54	1.27	24.93		315	60.81	3.48	24.37	
116	122.13	1.28	24.93		320	60.09	3.51	24.36	
118	120.76	1.29	24.93		325	59.37	3.55	24.35	
120-120	119.42	1.31	24.92		330	58.65	3.58	24.34	
122	118.10	1.32	24.92		335	57.93	3.62	24.33	
124	116.84	1.34	24.92		340	57.21	3.65	24.32	
126	115.64	1.35	24.92		345	56.49	3.69	24.31	
128	114.40	1.37	24.92		350	55.77	3.72	24.30	
130-130	113.24	1.38	24.92		355	55.05	3.76	24.29	
132	112.04	1.40	24.92		360	54.33	3.79	24.28	
134	110.84	1.41	24.92		365	53.61	3.83	24.27	
136	109.64	1.43	24.92		370	52.89	3.86	24.26	
138	108.44	1.44	24.92		375	52.17	3.90	24.25	
140-140	107.24	1.45	24.91		380	51.45	3.93	24.24	
142	106.04	1.46	24.91		385	50.73	3.97	24.23	
144	104.84	1.48	24.91		390	50.01	4.00	24.22	
146	103.64	1.50	24.91		395	49.29	4.04	24.21	
148	102.44	1.52	24.91		400	48.57	4.07	24.20	
150-150	101.24	1.54	24.91		405	47.85	4.11	24.19	
152	100.04	1.56	24.91		410	47.13	4.14	24.18	
154	98.84	1.58	24.91		415	46.41	4.18	24.17	
156	97.64	1.60	24.91		420	45.69	4.21	24.16	
158	96.44	1.62	24.91		425	44.97	4.25	24.15	
160-160	95.24	1.64	24.91		430	44.25	4.28	24.14	
162	94.04	1.66	24.91		435	43.53	4.32	24.13	
164	92.84	1.68	24.91		440	42.81	4.35	24.12	
166	91.64	1.70	24.91		445	42.09	4.39	24.11	
168	90.44	1.72	24.91		450	41.37	4.42	24.10	
170-170	89.24	1.74	24.91		455	40.65	4.46	24.09	
172	88.04	1.76	24.91		460	39.93	4.49	24.08	
174	86.84	1.78	24.91		465	39.21	4.53	24.07	
176	85.64	1.80	24.91		470	38.49	4.56	24.06	
178	84.44	1.82	24.91		475	37.77	4.60	24.05	
180-180	83.24	1.84	24.91		480	37.05	4.63	24.04	
182	82.04	1.86	24.91		485	36.33	4.67	24.03	
184	80.84	1.88	24.91		490	35.61	4.70	24.02	
186	79.64	1.90	24.91		495	34.89	4.74	24.01	
188	78.44	1.92	24.91		500	34.17	4.77	24.00	
190-190	77.24	1.94	24.91		505	33.45	4.81	23.99	
192	76.04	1.96	24.91		510	32.73	4.84	23.98	
194	74.84	1.98	24.91		515	32.01	4.88	23.97	
196	73.64	2.00	24.91		520	31.29	4.91	23.96	
198	72.44	2.02	24.91		525	30.57	4.95	23.95	
200-200	71.24	2.04	24.91		530	29.85	4.98	23.94	
202	70.04	2.06	24.91		535	29.13	5.02	23.93	
204	68.84	2.08	24.91		540	28.41	5.05	23.92	
206	67.64	2.10	24.91		545	27.69	5.09	23.91	
208	66.44	2.12	24.91		550	26.97	5.12	23.90	
210-210	65.24	2.14	24.91		555	26.25	5.16	23.89	
212	64.04	2.16	24.91		560	25.53	5.19	23.88	
214	62.84	2.18	24.91		565	24.81	5.23	23.87	
216	61.64	2.20	24.91		570	24.09	5.26	23.86	
218	60.44	2.22	24.91		575	23.37	5.30	23.85	
220-220	59.24	2.24	24.91		580	22.65	5.33	23.84	
222	58.04	2.26	24.91		585	21.93	5.37	23.83	
224	56.84	2.28	24.91		590	21.21	5.40	23.82	
226	55.64	2.30	24.91		595	20.49	5.44	23.81	
228	54.44	2.32	24.91		600	19.77	5.47	23.80	
230-230	53.24	2.34	24.91		605	19.05	5.51	23.79	
232	52.04	2.36	24.91		610	18.33	5.54	23.78	
234	50.84	2.38	24.91		615	17.61	5.58	23.77	
236	49.64	2.40	24.91		620	16.89	5.61	23.76	
238	48.44	2.42	24.91		625	16.17	5.65	23.75	
240-240	47.24	2.44	24.91		630	15.45	5.68	23.74	
242	46.04	2.46	24.91		635	14.73	5.72	23.73	
244	44.84	2.48	24.91		640	14.01	5.75	23.72	
246	43.64	2.50	24.91		645	13.29	5.79	23.71	
248	42.44	2.52	24.91		650	12.57	5.82	23.70	
250-250	41.24	2.54	24.91		655	11.85	5.86	23.69	
252	40.04	2.56	24.91		660	11.13	5.89	23.68	
254	38.84	2.58	24.91		665	10.41	5.93	23.67	
256	37.64	2.60	24.91		670	9.69	5.96	23.66	
258	36.44	2.62	24.91		675	8.97	5.99	23.65	
260-260	35.24	2.64	24.91		680	8.25	6.03	23.64	
262	34.04	2.66	24.91		685	7.53	6.06	23.63	
264	32.84	2.68	24.91		690	6.81	6.10	23.62	
266	31.64	2.70	24.91		695	6.09	6.13	23.61	
268	30.44	2.72	24.91		700	5.37	6.17	23.60	
270-270	29.24	2.74	24.91		705	4.65	6.20	23.59	
272	28.04	2.76	24.91		710	3.93	6.24	23.58	
274	26.84	2.78	24.91		715	3.21	6.27	23.57	
276	25.64	2.80	24.91		720	2.49	6.31	23.56	
278	24.44	2.82	24.91		725	1.77	6.34	23.55	
280-280	23.24	2.84	24.91		730	1.05	6.38	23.54	
282	22.04	2.86	24.91		735	0			

As it is often convenient to know the offset in feet from any chord point on the spiral to the tangent, this has been prefixed, in terms of P , to the general table of deflections in terms of D , and as these ratios are simple they soon become fixed in one's mind.

For highway work it is not usually necessary to spiral curves of more than 2000 ft. radius, and the table of 50 ft. chords was intended for use only as circular curves, but in private way, where high speed is at least legal, the values of P and Q may be readily determined from the expressions given, and the deflections taken from either table. It may also be an improvement in certain cases to double the chord length for the longer radii in the table of 25 ft. chords. This can be done with very little calculation, as it simply multiplies P by 4 and Q by 2, not forgetting that D will also be doubled if R is to remain unchanged.

Other modifications will no doubt suggest themselves to any user of the tables, as roadbeds continue to improve and speeds increase.

ASH CREEK BRIDGE.

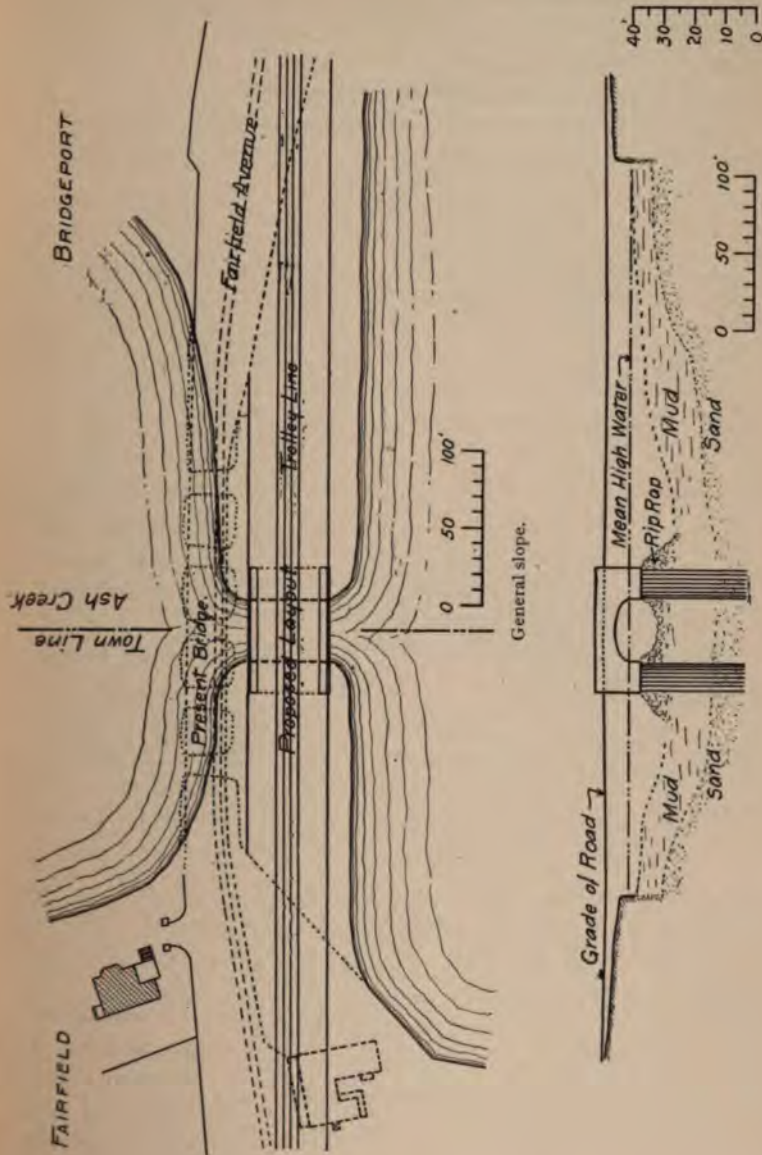
By Edward E. Minor.

Ash Creek is a tidal stream, having a watershed of about eight square miles. It lies west of Bridgeport, and forms in part the boundary line between the towns of Bridgeport and Fairfield. At Fairfield Avenue, where the arch, which is the subject of this paper, is being constructed, the "Creek" has a width of about 400 feet. The rise and fall of the tide is about three feet.

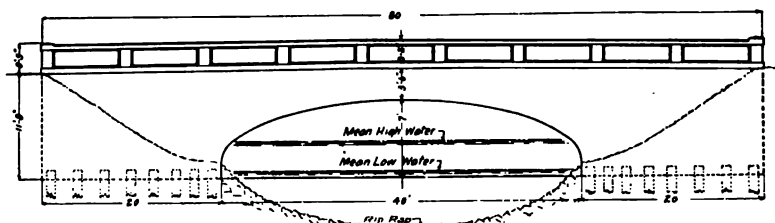
The present bridge consists of wooden stringers resting on large piers, built of rough stone and well protected by riprap. There are five openings, each about fourteen feet in width. The water passing through these openings had taken the soft mud out to a depth of about eight feet below low water. Beneath this there was about fifteen feet of stiff mud, and then what appeared to be fine sand down to rock.

The new bridge replaces the five openings of the old bridge by one span of forty feet. It was first proposed to build, and plans were drawn, for a reinforced concrete bridge of beam construction, as it was considered unwise, at first, to place a necessarily flat arch on piles in mud, where the abutments could not be depended upon to resist horizontal forces. However, the elliptical arch presented features of design and appearance which made it appear better adapted for the place and led to its being chosen, after some novelties in design had been introduced, which obviated any dependence being placed on the foundations to resist thrust.

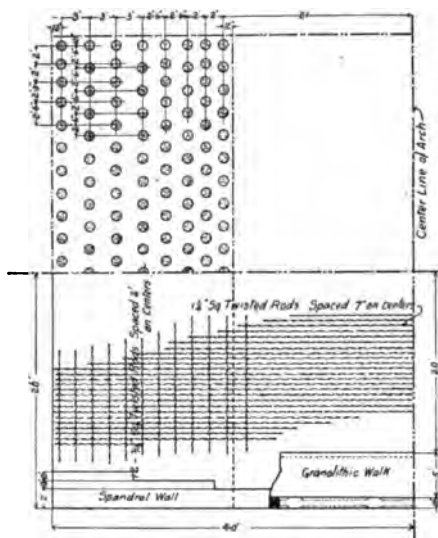
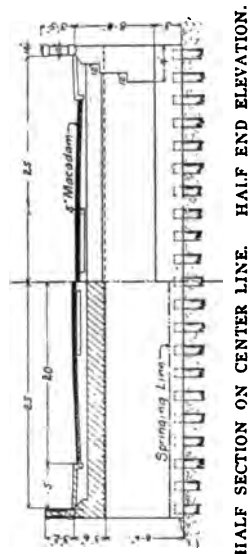
The intrados is a five-center curve, closely approximating an ellipse. The arch is two feet thick at the crown, and has a rise of seven feet above the springing. The abutments are low and unusually wide on the base. The foundations of the arch consist of piling, about thirty-five feet in length, driven to hard bottom. Outside the piles riprap was placed, forming a rock fill, completely around each abutment. The space



Profile.
CONCRETE ARCH—ASH CREEK, BRIDGEPORT.



ELEVATION OF ARCH.

QUARTER PLAN OF PILING.
QUARTER PLAN OF ARCH.

HALF SECTION ON CENTER LINE. HALF END ELEVATION.

between the piles was then filled with beach gravel and sand, finishing on top with a six-inch layer of sand on which to place the concrete. The first four rows of piles on the front of the abutment and the first two rows under the wing walls were of selected sticks and were very carefully driven.

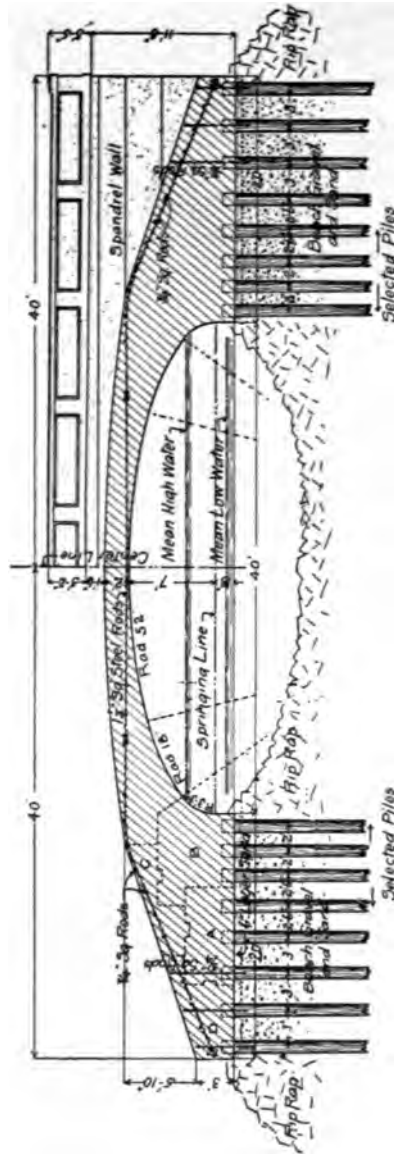
The steel reinforcement of the arch proper is of twisted steel rods, $1\frac{1}{4}$ inch square, spaced seven inches on centers, passing directly through the arch. These rods are given a slight inverted camber. They pass close to the intrados of the arch at the center, and approach the extrados at a point above the second row of piles in the foundation. Here they

bend downwards and extend through the concrete to the back of the abutment, where they are anchored. These rods are shown in the sectional elevation of the arch. If the structure acts as an arch, the steel reinforcement is where it is needed to resist tension in the concrete; near the intrados at the crown and the extrados at the haunches.

The tendency of these rods is to throw the weight of the arch on the front rows of piles, to lift the back of the abutment, and to push the piling back. To prevent this the abutment was made quite wide and flat, and the piles extended up into the concrete. The outer end is anchored to the piles by means of twisted steel rods driven into the piles. The main anchor rods, passing through the abutment near the top, enable the weight of the fill above to act as a counter weight for the weight of the arch.

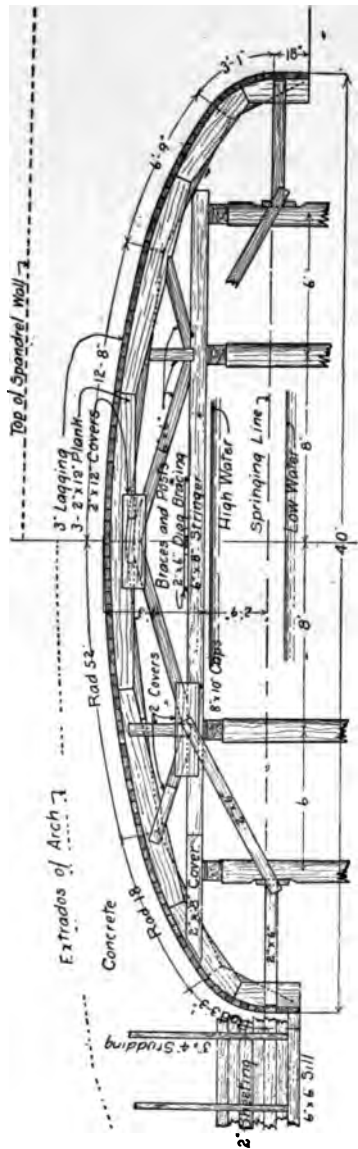
The arch then virtually acts as a cantilever; the position of the reinforcement enables the center of the arch to act as a beam supported on two cantilever arms, which are balanced by the width of the abutments. The fastening of the end of the abutment to the piling was an additional safeguard. The novel feature of the design is the utilizing of the steel reinforcement in the concrete to resist the thrust of the arch. No reliance is placed on the foundation to resist horizontal thrust, but only vertical forces.

The arch is being built by the City of Bridgeport, P. Kennelly, Director of Public Works, W. W. Starr, City Engineer. It was designed by Albert B. Hill, Consulting Engineer. The writer is engineer in charge. The contractors are the Standish Stone Co. of Bridgeport, Conn.



Note - Abutment constructed as
 shown by Letters A B C D 1-2½-5 Concrete.
 Arch constructed in three
 longitudinal slices 1-2-4 Concrete.
 2" Inverted Camber in 1½" Rods.
 All rods medium steel. Twisted.

SECTIONAL ELEVATION CONCRETE ARCH—ASH CREEK.



ELEVATION OF CENTERS ASH CREEK BRIDGE.

REINFORCED CONCRETE TANKS.

By Charles H. Ferry.

The New Haven Gas Light Co. has, in connection with the work of enlarging its plant, erected three tanks for the storage, respectively, of oil, tar and ammoniacal liquor. Each of these tanks is fifty feet in diameter, twenty feet in height and holds approximately four hundred and forty thousand gallons.

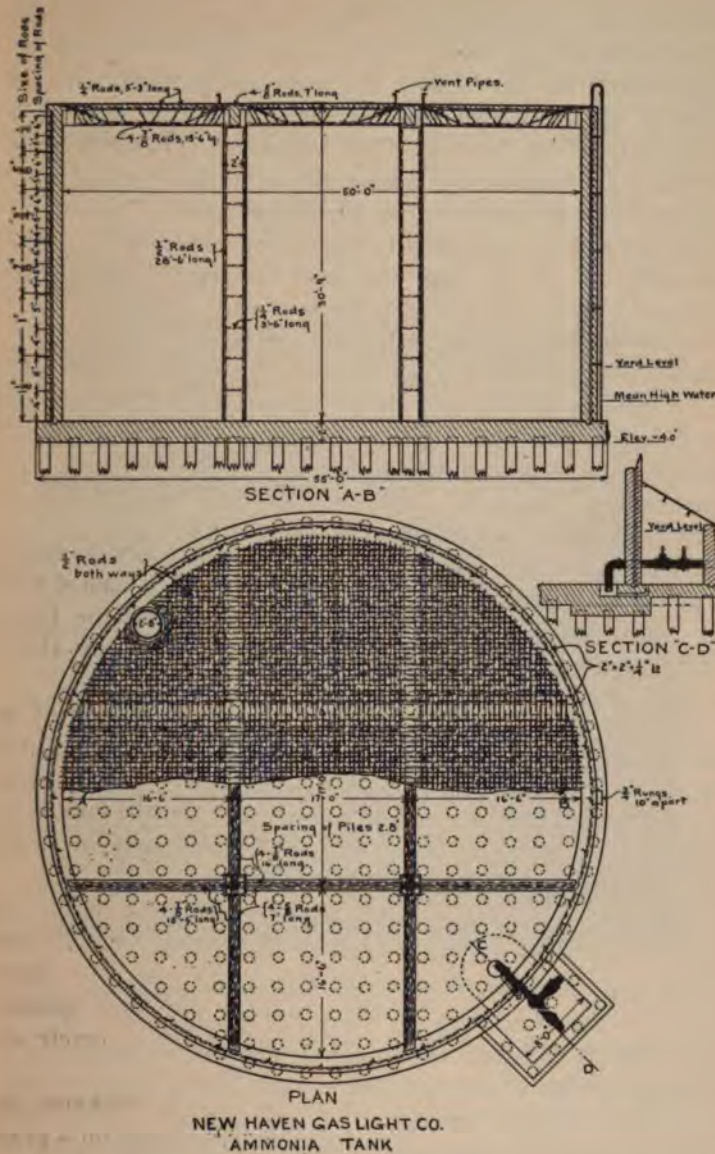
The oil and tar tanks were constructed of steel plates and have a steel plate roof supported by trussing beams radiating from a central post, the whole structure resting on a pile and concrete foundation.

Owing to the strong corrosive action of ammonia on steel it was decided to use reinforced concrete for the last named tank, and a contract for its construction was made with the Eglee-Bunting Co. of Boston, the contractors for the New Haven Water Company's new filtration plant.

The tank is located on the wharf, within a few feet of the face of the dock on New Haven, as the fill of material is quite porous, oyster shells forming a large part of it, the ground water rises and falls with the tide, high water in the tank being about ten inches below high water in the river and low water about two feet above mean low water outside.

The tank is built on a pile foundation, the piles being two and eight tenths feet apart, each one and one half feet in diameter, and are cut off three and one half feet below mean high water, or about six inches above low level of the ground water. The bark and loose splinters were removed from the heads of the piles and the concrete was filled in around them to a depth of about six inches.

The bottom of the tank was made ten feet in thickness, put in in three layers of eight inches each, and was built on a grade of three inches in fifty feet, sloping to a square hole on the lower side of the tank twenty inches in diameter and twelve inches in depth, for the removal of the tar which separates out of the liquor.



The sides of the tank are eighteen inches in thickness for the entire height; the thickness being made uniform for convenience in constructing the forms.

The steel reinforcement consists of $2'' \times 2'' \times \frac{1}{4}''$ angles placed vertically five inches from the outside of the tank, and spaced about five feet apart. To these are fastened horizontal hoops of square twisted rods varying in size from $1 \frac{1}{8}''$ at the bottom to $\frac{1}{2}''$ at the top. The hoops are accurately spaced and held in position by wiring them to the vertical angles through holes punched in them for that purpose.

The sizes of the rods vary by eighths of an inch and, in order that each rod of the same size shall be strained substantially the same amount, the spaces between the rods vary also.

Assuming that each rod takes the pressure of its own particular section of the tank, each will be strained, when the tank is full, from ten to fourteen thousand pounds per square inch; the concrete not being figured as taking any of the bursting pressure but, of course, it will distribute the strains and tend to equalize them in the rods.

The rods were each about 33' in length, five rods to a hoop, and were connected together by turn buckles; the rods being so placed as to break joints. The hoops were placed outside of the angles, leaving a space between the rods and the outside forms sufficient for the necessary spading of the concrete.

The wall was built in six sections, each five feet in height. To secure a tight joint between the wall and the bottom of the tank, and between different sections of the wall, a groove, about four inches in width and depth, was made at each joint. This was filled and the surface of the old concrete was covered with a thin layer of mortar composed of one part of cement and two parts of stone dust. Before doing so, however, the surface of the old concrete was scrubbed with wire brushes and thoroughly washed with water to remove all soft or loose material.

The roof is built of reinforced concrete slabs resting on beams of the same material supported by the side wall, and four columns each two feet square. The reinforcement in the columns consists of one $\frac{1}{2}''$ rod in each corner connected by a horizontal rod every three feet.

In the beams there are four $\frac{7}{8}''$ rods, and the beams are made continuous by four $\frac{5}{8}''$ rods over each column. The roof slab contains a $\frac{1}{2}''$ rod every six inches both ways.

The forms for the wall were of spruce boards with slightly beveled joints, placed vertically, and fastened to ribs sawed to

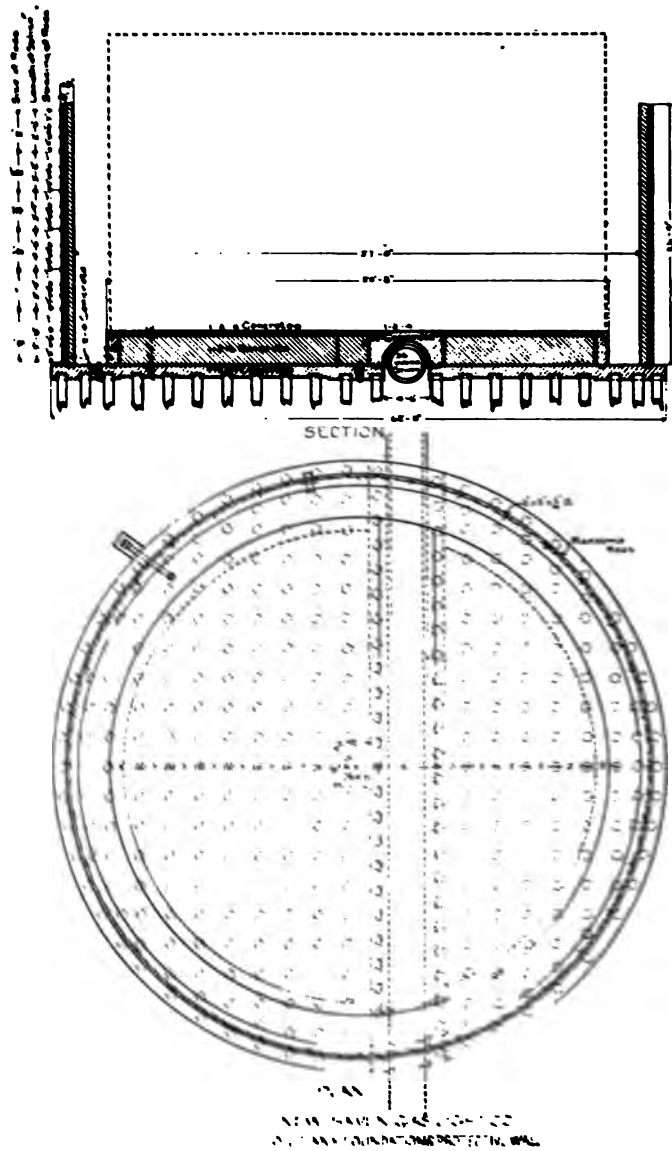
an arc of a circle of the required diameter. The inside forms were made continuous from bottom to top, but the outside forms were made in sections five feet in height and about twenty-five feet long, so arranged that they could be taken apart and used over again; each set of the outside forms being used twice. The outside and inside forms were connected together by bolts made in three sections joined by sleeve nuts; the middle section of the bolt and the two sleeve nuts being allowed to remain in the concrete.



PHOTOGRAPH OF TANK DURING ERECTION.

A small valve chamber with concrete walls and a wood roof joins the tank on one side. Two manholes in the roof afford access to the interior; and a one inch pipe built into each panel of the roof formed by the beams provide for the egress and ingress of air as the tank is filled and emptied with water.

The concrete used in the work was composed of one part of Atlas cement, two parts of fine pit sand and four parts of trap broken to pass an inch and a half screen and remain on a sieve with $\frac{1}{4}$ " mesh.



The outside of the tank was given a coat of grout composed of cement and sand and covered with soft wood floats; the inside was treated in the same manner with a neat cement grout which contained a small quantity of soft soap and alum.

In order to satisfy the requirements of the fire department, the oil tank is provided with a protective wall of reinforced concrete built around the steel tank forming an angular space three feet in width and twenty-six feet in height, to hold the oil in case of a leak in the inner tank, and thus preventing it from running out into the harbor. This wall is fifteen inches in thickness, and is constructed in the same manner as the wall of the ammonia tank except that the sections of the hoops were spliced by lapping the ends instead of joining them by turn buckles as in the case of the ammonia tank.

When the contracts for these structures were made it was expected that both of them would be completed before cold weather, but, owing to unexpected delays in getting the piles driven for the ammonia tank and the inability of the contractor for the steel work to secure prompt delivery of material, the ammonia tank was not completed until about the first of January, 1905, and the protective wall of the oil tank was not built until last summer.

The contractors were not restricted as to the method of doing the work, the specifications simply stipulating that the concrete should not be poorer than a 1 : 2 : 4 mixture. The contract, however, required that the tanks should be so built that they would stand a test of being filled with water for three days without leaking.

Owing to the severe cold weather at the time the ammonia tank was completed, this was not tested until last spring. About two days after it was filled, water began to appear on the outside of the tank at the third joint above the bottom and, in a few days, water was seeping through this joint about one third of the way around the tank and the top joint was also leaking slightly for about ten feet in length.

Wet spots also began to appear at points intermediate between the joints, but these were generally at points where there were bolts for holding the forms together.

It was thought that the efflorescence of the lime in the cement would eventually stop the leaks, and this proved to be the case except in the case of the leaks through the joints. These not showing any material improvement, a V-shaped groove was cut in the inside of the tank along the leaky joints and this was filled with a rich mortar; a treatment which, while not giving the

results desired, materially improved the conditions, and the tank was put into commission.

There was one curious feature in connection with these leaks which we have never been able to satisfactorily explain. The leaks in the two joints referred to were on nearly opposite sides of the tank; when the lower joint appeared at its worst the upper showed scarcely any leakage and vice versa.

If one does not know what to do in a certain case, it is well to know what not to do, and there are two "don'ts" which might be given as a word of caution to any who may have occasion to build concrete tanks. Don't build them in sections, but make them monolithic if possible, and don't build them in freezing weather. To one or both of these causes can probably be attributed most of our troubles in connection with this work.

THE REBUILDING OF THE HOUSATONIC RIVER BRIDGE,

SANDY HOOK, CONN.

By Alfred H. Terry.

The question of speed of construction is one which so frequently occupies the attention of all civil engineers that the manner and methods employed in replacing Bridge No. 105 of the New York, New Haven, and Hartford Railroad Company, which spans the Housatonic River at Sandy Hook and which was recently destroyed by fire, should prove of interest to this society.

This bridge was originally a deck wooden truss of three spans, total length 500 ft. and 70 ft. from base of rail to low water level. The fire which destroyed it was caused by a live clinker which dropped from a locomotive and lodged on the northwest corner of the bridge seat just under the junction of the end post and the bottom chord. The bridge crossed the river running east and west. The fire was discovered at 10.45 A. M., Sunday, November 19th. There was a strong wind blowing from the northwest and the timber was very dry on account of a long-continued drought. Combustion was so rapid that all efforts to check the fire proved vain, and at 11.55 A. M. the bridge was totally destroyed and in the river.

Word was immediately sent to New Haven and by 6 P. M. of the same day, under the direction of Mr. Edward Gagel, Chief Engineer, Mr. W. H. Moore, Bridge Engineer, and Mr. W. J. Black, Engineer M. O. W., a combination pile and frame trestle with openings for ice way had been designed in its main features. Meanwhile word had been sent to all bridge supervisors in the western district to forward at once to Sandy Hook all timbers and piles of the various sizes needed which they had in stock. At the same time work trains were despatched to either end of the bridge to clear the wreckage. We were fortunate enough to possess a small water pile driver with float in three sections, which was also ordered to Sandy Hook at once.

After looking over the ground Monday it was decided to pile the center and east spans as far as possible and to build the west span of frame construction. This last was made necessary by the fact that the bottom of the river in this span was rock ledge. The trestle as planned in New Haven was to be built in three tiers. The ice ways, four in number, one each in the east and west span, and two in the center span, were to be one tier in height and to be each spanned by four



VIEW LOOKING SOUTH, NOV. 20.

girders. These girders were to be placed one under each rail, and one under each batter post of the intermediate tier.

Monday, Tuesday and Wednesday were devoted to clearing the wreck and unloading plant and material. Thursday saw the work actually started.

The plant employed the first week was as follows:—

On the east side a hand pile driver, a water driver, and for two or three days a steam wrecking derrick which was used to lower the heavier portions of the plant to the river bank. This does not take count of two work trains, which were used to bring

material, clear away the wreckage, etc. On the west side there was a small derrick car, and a stationary hoister, which latter was set up on the west abutment. There was also a switch engine to handle the derrick car and bring material to the bridge and a work train for bringing material, etc. After the first week we used a patent car pile driver for power on the east side and had the American Bridge Company's derrick car No. 204 on the west side. This derrick No. 204 had a 50 ft. boom and capacity of 50 tons with boom at 30 degrees. The



VIEW LOOKING EAST, NOV. 20.

force at work after November 24th consisted of about 100 carpenters and 100 laborers, equally divided as to the two sides of the river. This force was in large part brought in daily by trains from Bridgeport, Waterbury, Danbury and one gang of thirty-five laborers came from East Hartford. We were able to board only about seventy men in Sandy Hook. These men were all bridge carpenters however.

Most of the work was done between 6 A. M. and 5 P. M. (daylight to dark), although the pile driving was carried on

night and day until completed. Such other work as could be done at night was done where necessary to insure no delay to the progress of the following day.

The trestle, as mentioned above, was built in three tiers. The top tier was a four (4) post frame bent with vertical posts 21 ft. long. The intermediate tier was a six post frame bent with vertical posts 20 ft. long, except where bents came on top of girder spans. The bottom tier was, as stated above, a combination of pile bents, frame bents and girder spans. The



CONSTRUCTION AT WEST SPAN.

frame bents were of eight posts each and the pile bents of nine piles each. All bents were spaced 12 ft. centers except in the case of the girder spans and on a skew of 60 degrees. The girders had their bearings, in the case of the east and west openings, in a double bent at either end. In the center openings where two girder spans came together the bearing at the ends was the same as in the east and west spans. The center bearing, however, was on a triple pile bent.

The west span was built as follows:—First the sill was bedded, then the posts erected, then the cap placed, and the



CONSTRUCTION AT WEST PIER SHOWING FRAME HORSES SUPPORTED ON RIPRAP ON WEST SIDE AND PILE DRIVER AT WORK IN CENTER SPAN.



DECEMBER 5 P. M.



DECEMBER 6 NOON.



VIEW SHOWING METHOD OF CONSTRUCTION OF EAST SPAN.

whole ended up by block and fall, power being furnished by the hoister set on the west abutment. Where the sills came in the water, the bottom was first levelled off with small stone. The higher tiers were put together on the tier next lower and ended up in the same manner. To do this it was necessary that each of the two lower tiers should be kept two bents ahead of the one next higher. All timber was cut on the track level and lowered into position by the car derrick until the arrival of the American Bridge Company's derrick. The girders for the west span were unloaded by hand and taken on skids to their resting place, power being applied through block and fall from the hoister. These girders were 55 ft. long and 4 ft. 6 in. deep. The center pair came riveted together and were placed without cutting them apart. After the arrival of the American Bridge Company's derrick all bents were put together ashore and carried out by the derrick and placed bodily. The iron of the center span was placed by the derrick. The girders of these spans were 55 ft. and 46 ft. long, respectively. The west span and the two higher tiers of the center span including girders were built by the west side force.

On the east side the construction and method were both different. All except five bents of the bottom course were pile bents. The girders 43 ft. long were lowered to the river bank by the steam wrecking derrick mentioned above and hauled into position by block and fall with the land driver furnishing the power. This gave a level surface to work on and the next course was put together and laid flat on the course beneath before a bent was raised. All the timber on this side was cut on the river bank just south of the bridge and from there carried to the foot of the abutment, from which point each stick was telegraphed to its destination by a fall running from the patent driver on top of the abutment to the east pier. The bent nearest the pier and farthest from the driver was put together first and hauled into position with its sill resting on its bearing on the rangers of the tier below. The next bent was then framed and hauled into its position with its top resting on the first bent, and so on. When the entire tier was thus in place, each bent, beginning with the one nearest the abutment, was ended up and stayed in position, after which the rangers were telegraphed into position and dowelled down. The top course

was placed in the same manner. On this tier, after the timbers had been cut, fourteen horses were carried to their destination piecemeal, put together, and erected in thirteen hours.

Each bent of the entire structure was braced transversely by a single X brace of 3 in. by 10 in. pine spiked, with $\frac{1}{2}$ in. by 8 in., boat spike. The structure was braced longitudinally by a triple row of ranges between the intermediate and bottom tiers and a double row of rangers between the intermediate and



BRIDGE PRACTICALLY COMPLETE.

top tiers. In addition to this, there was a single row of X bracing placed longitudinally for the two highest tiers. No dowels were used except for the rangers and track stringers and no mortise joints at all; all joints being made by spiking a plaster of 3 inch plank to cap and post and sill and post. Chocks were placed under all vertical posts between cap and sill.

On the west side the track stringers, ties and rails were carried out with the top tier, two methods being employed. Before the arrival of the American Bridge Company's derrick,

the stringers, ties and rail were carried out by the small car derrick and placed piecemeal. After the arrival of the American Bridge Company's derrick, a panel of track 36 ft. long was put together ashore, carried out as a whole and placed bodily. On the east side the top tier was complete before any of the stringers were placed. Here the stringers were all framed on the river bank and hauled into position by the patent driver, after which the track forces placed the ties and rails.

The total amount of square timber was 270,000 bd. ft. exclusive of waste, which was very small. Of this amount 90,000 bd. ft. was in stock at the time of the fire and the remainder was bought in the market and forwarded to the work as required. There was practically no delay to the work after November 23d on account of the lack of material, for which credit is due the Purchasing and Transportation Departments.

The first regular train crossed the new structure December 7th at 2.46 P. M., just seventeen days and three hours from the discovery of the fire, and about fourteen and one-half days from the time the first timber was framed.

STREET SCENES IN MANILA AND LIFE IN THE PHILIPPINES.*

By Desmond Fitzgerald, Consulting Engineer.

I wish to thank you for this hospitable reception and most complimentary allusion to my work. You know it is always a great aid to a man to give him a good send-off, but much as I need that, I really feel already more or less at home with the Connecticut Society of Civil Engineers, with many of whom I already have such a pleasant acquaintance.

My only wish is that I may be able to give you as much information as the flattering words of your chairman may lead you to anticipate. I do not know whether it is practicable to tell you much that is new about the Philippines; the only thing that I can do is to describe scenes as I saw them. My address will be really of the nature of an informal illustrated talk. About two years ago I was sent there by the government to make reports on the water supply and sewerage systems of Manila. While there I took about six hundred photographs, particularly of street scenes in Manila, and the views you will see this afternoon are taken from these pictures.

The Philippine Islands have been much in evidence during the last few years, since they have been acquired by the United States, and, as is quite natural, there exists an earnest desire on the part of the people to form some conception of what they are really like. You cannot get a complete idea from reading histories of the Islands, or from accounts of their inhabitants, however accurately they may be portrayed. In reality these descriptions are very confusing. On the one side we hear that the people are gentle, highly civilized, ready for self-government, and oppressed by an invader. On the other hand,

* Mr. Fitzgerald's lecture was illustrated by numerous beautifully colored stereoscopic views; which, unfortunately, the Society is unable to reproduce.

we hear that the Islands are composed of savage tribes, sunk in ignorance and darkness, into which the light of civilization will perhaps have to shine for a century or more in order to illuminate their minds so that they will be in a condition of self-government. Now with two such divergent views, what are we to think? I hope by showing you these pictures of actual scenes to be able to give you an opportunity to take a little journey as it were and to see things exactly as if you were there; statistics will be avoided as far as possible.

Manila is almost a perfectly level city: it is built on the delta of the Pasig river. It is only a couple of feet above the ocean. The rise and the fall of the tide is only about a foot and a half. You can readily understand that when there is a very heavy freshet in the river the city must be inundated. I was in the Philippines during the dry season, but since I left there has been one rainfall of 17" in about thirty hours, and as a consequence practically the whole city was under water, which was three or four feet deep in the streets.

As you may expect in a city built upon a delta formation there are large ditches or canals extending in many directions throughout Manila. They are used for purposes of navigation and for transferring merchandise in boats of small draft from vessels in the harbor to different warehouses on the lines of the canals. On the southerly bank of the river and one of the first objects to attract one's attention as we enter the city, are the fortifications around the old city of Manila built by the Spaniards several hundred years ago. They are about forty feet in height and extremely solid and well constructed and of dark color. They enclose but a small part of the city, but are entirely built over with houses, churches and shops, of masonry construction and Spanish architecture. The total population of the city is about 230,000, largely natives, with a sprinkling of Chinese, English, Americans and other foreigners. The Government, in order to gain access to this part of the city, has made a few wide holes through the walls, for the purpose of building wider streets. The old entrances were through very narrow passageways where a driver had to come to a stop if there was a team coming in the opposite direction. These slides will give you a better idea of the situation than any I can elaborate.

You will notice these gentlemen in white cotton or linen clothes. Everybody wears the thinnest and coolest garments in Manila. The first thing to be done on reaching the city is to buy a half dozen suits which are nicely made to order for four or five dollars a suit. Washing is inexpensive so that a clean suit is worn every day. The Arjamiento is the Government building, formerly the seat of Spanish rule and now used by the Philippine Commission for their offices. The architecture is simple and beautiful and the interior finish and decorations are in full harmony with the fine façade. The large Assembly hall is one of the finest rooms I have ever seen. It is finished in white with touches of gold and the walls are covered with old rose brocade.

You can see as you pass from one to another of these street scenes how clean the pavements are. If the Government is praised for nothing else, it should receive credit for having produced remarkably clean streets. Even in the suburbs of the city the streets are in excellent condition: in fact I know of no American city where the streets are kept as clean.

Inside of the old walled city there are a great many churches, many of which are extremely interesting. The cathedral is a very large and substantial building and parts of it are very fine. Anyone, I think, would be surprised to see in a city like Manila a building of this character. The interior is, as you see, magnificent in proportions and design. Of course earthquakes are the great enemies of such massive construction, and when a heavy masonry building is shaken down it is apt to result in great loss of life; on the other hand, the houses of native construction are so light and elastic that you may generally crawl out from under them without serious results. The Spaniards, during their occupation, did a great deal in the way of establishing churches all over the Islands. They have hardly received proper credit for this work. Not only did they build churches, but many other substantial buildings, bridges and roads.

You will notice in these pictures that children are everywhere in evidence; they are very fond of having their pictures taken, and although some may be invisible when the camera is set up there is sure to be three or four spring out of the ground before the bulb is pressed. They sometimes serve as a scale

for judging the dimensions of a picture, as for instance in these beautifully carved doors of the church of St. Augustine which are said to be very old. This is the interior of that church taken one Easter Sunday morning by candle light and requiring seventeen minutes exposure. During that time the audience was quiet and they show well in the photograph, but the preacher was so active that he turned out to be a round bundle of cotton wool when he was developed. In the choir loft I found this beautiful piece of old Spanish carving, said to be three hundred years old, and one of the most remarkable lecterns I have ever seen. The monastery connected with this church is very extensive and covers a whole square.

In the old walled city of Manila the streets are all of the same general type, so I will show you only one or two of them; the houses all look alike, and are founded on the idea of adaptability to the climate. Yet there are differences, and anyone who had the time to study and classify them would find it an interesting problem; the upper story is generally bracketed out from the main wall, and this false front, as it were, is provided with sliding windows or blinds which keep the sun from shining into the bed-rooms. It struck me that we had not profited from the long experience of the Spaniards in tropical countries in building some of our own houses in Manila, many of the latter being entirely inappropriate to the climate. The principal bridge connecting the two portions of the city, which are separated by the Pasig river, is called the bridge of Spain; it is a massive structure of stone arches over which large crowds are constantly passing, and here you will see representatives of all nations. The native boats, which are constantly passing back and forth on the canals, are very picturesque. They are poled by nearly naked men, who walk on bamboo projections which are bracketed out from the sides of the boats, and by means of long poles the heavily-laden bancos are propelled. The merchandise is covered by bamboo mats, in fact almost everything in the Philippines is made of bamboo. The motion of the boats is naturally very slow and deliberate. I suppose there are 25,000 people living on these boats in Manila; they make very picturesque and artistic subjects for those who are fond of color and movement. The boatmen themselves are athletic, and the play of their muscles and their absorption in the work is very entertaining.

The streets are carried across the canals by small arch bridges of masonry. The Spaniards are good masons. Here is a picture showing natives carrying water in barrels and buckets from the city hydrants to their houses. Their buildings as a rule are of such a character that they cannot well have plumbing in them.

Perhaps this is a good place to say a few words in regard to the water supply. In 1743 a public-spirited citizen of Manila bequeathed the sum of \$10,000 for the construction of a public water supply. This fund was so well managed that in 1867 it amounted to \$355,700 and at that time the present works were started and they were completed in 1882. Water is pumped from the Mariquina river, a few miles above the city, and delivered to a covered reservoir three-quarters of a mile outside the city limits. This is a particularly fine piece of construction. It holds 10,000,000 gallons and is excavated entirely out of a soft rock. The roof is eight feet in thickness. From this reservoir water is conveyed to the city through a 20-inch cast-iron main. In addition to the bad quality of the water, the supply is insufficient for the present demands of the city and it is proposed to go to a new source and to build works better adapted to meet the wants of the city. One of the most serious troubles connected with the drinking of water in the Philippines is the presence of amoeba in the water. This little protozoan is the source of more trouble than I can well describe. He first produces dysentery, and if this is not cured at once, in the course of a couple of years death ensues. I caught this disease myself soon after my arrival in Manila and was obliged to go through a rather severe course of treatment for three weeks before all of the amoeba could be eradicated from my system. To ensure safety it is necessary for every one visiting the Philippines to see that all of the water which they drink is boiled or else to drink nothing but bottled water. At present there is no real sewerage system in Manila, but one has been planned and is soon to be carried out, the appropriations for that purpose having been made.

I will now show you several pictures of the people as one meets them on every hand. The women won my hearty respect; they always appeared to be busy with domestic duties or aiding their husbands in business matters. The costumes worn are

adapted to the climate. Here you will see the process of winnowing rice. The houses are extremely simple and so constructed that the air will circulate freely through them. The frames may be entirely of bamboo and bamboo matting forms the sides of the houses. The lower stories are generally used for the storage of carts or tools and are often open so that the hens and pigs may roam freely under the living part of the house. The roofs are thatched with Nepa palm leaves.

The caribou is the leading domestic animal in the Philippines. He is indispensable. He is the ox, and the horse, and is one of the most patient and hard-working animals I have ever seen. It is remarkable to see how well they can be driven through the thickly crowded streets and guided with but one rein. He is amphibious and will die if not allowed to wallow in the water several times a day.

The forests in the Philippines are filled with fine timber. I have never seen a greater variety of hard woods. Many of them are susceptible of a high polish and some of the trees are so large that a dining table is frequently made from one section of a tree. Here is a Filipino sawmill run by Chinamen, who do a large share of the framing and carpenter work in Manila. A great deal of the heavy work in the city is done by this race. They seem to have a monopoly of loading merchandise from the wharves to the steamers.

The Filipinos are very fond of cock fighting, and they sometimes carry the birds around with them in the streets. The Government does not allow them to have cocking mains within the city limits, but just outside the line there are very large buildings devoted to this sport.

The Pasig river, flowing as it does directly through the heart of the city, is one of the most impressive topographical features. In many places the houses are built close to the water and even project beyond the brink. In the finer houses these projections take the form of terraces and on a bright moonlight evening the views from these terraces become fairly enchanting, and occasionally music may be heard in connection with the various forms of enjoyment or entertainments in progress. In the lower beaches of the river before it empties into the bay, its banks are bordered by storage warehouses or manufactories and here the shipping is thickly

crowded for room. So great is the necessity for more wharf room that the Government is creating a large area for wharves on the southerly side of the river and behind the breakwater, which wards off the deadly typhoons.

As everyone knows, there are many different races or tribes in the Philippines and they differ largely, both in their physical development and in their social condition, habits and customs. I was fortunate in being able to get some pictures of the Bogobos, a peaceable people living near the warlike Moros on one of the southern islands. They were on their way to St. Louis and were arrayed in elaborate bead work. The people around Manila are known as Tagalogs, and farther north in the island of Luzon are the Igorrotes, a hardy, muscular people who live in the mountains and are accustomed to carrying heavy loads upon their backs. I made a trip into Benguet, the land of the Igorrotes. It is here that the Government is endeavoring to form a summer capital. Some of these views were taken on the well known Benguet road, a very difficult mountain highway leading to the interior and rising to the tableland four thousand five hundred feet above the sea.

I have added a few slides to give an idea of the picturesque character of much of the scenery in the Philippines. There are beautiful mountain ranges, rivers and valleys in every direction. Many of the mountains rise to a height of 8,000 feet and afford every variety of outline. The valleys are fertile and capable of supporting a large population. Whether the average native will rise in time to a conception of his opportunities and become capable of taking his place alongside of the vigorous and highly civilized peoples of the world, I leave the future to determine.

DISCUSSION.

SEWAGE DISPOSAL AT WATERBURY.

MR. CAIRNS: "I might say that in the winter of 1893-1894 this matter was brought up in the General Assembly. I think it came up in the form of a bill authorizing the city to issue bonds to build works to take care of its sewage, and it was understood that one of the methods used might be the construction of a trunk sewer down the Naugatuck valley, to discharge off Milford Point, and at the hearing before the committee the different communities down the river, and communities along the shore, like Woodmont, and along in there, were represented, and were very violent in their opposition to such a method of treatment. It did not seem at all probable that any legislation authorizing such a method of disposal would stand any chance of getting through.

"I would like to say in further reference to the plant at Columbus, Ohio, that after carrying on these experiments in the way I speak of they decided to use a method of disposal consisting of sprinkling filters somewhat upon the same general principle as this one illustrated in the photograph, and they expected to be able to pass sewage through those filters at the rate of two million gallons per day per acre. That compared with the standard method of treatment by intermittent filtration through gravel, where from only one to two hundred thousand gallons per day per acre is considered a very good rate, gave a much larger result. You see with the other plan an acre does fifteen or twenty times as much work, and if the area is limited, or proper material is hard to get, as it is in Columbus and Waterbury, it gives a great advantage. That higher rate of disposal is something of immense importance. As I understand it, at Columbus they could not get any sand suitable for intermittent use except by bringing it by train from Lake Erie, which, of course, made the expense prohibitory.

"There has been a change in the period at which No. 2 is run. It is run on a period of twenty-four hours."

A MEMBER: "Mr. Cairns, can you explain right there why you made that change?" Mr. Cairns referred to Mr. Taylor, who answered.

MR. TAYLOR: "The change was made hoping to reduce the amount of nitrites and nitrates in the tank effluent. Under the sixteen-hour period the septic tank effluent contained dissolved oxygen, and the tank period was lengthened in order to increase the putrefactive activity. The presence of nitrates in septic sewage is rare and dissolved oxygen is never found in active tanks. I believe in Exeter, England, both nitrites and nitrates were found in the septic sewage.

"We dislike to find it necessary to lengthen the periods for the reason that an increase in the period means an increase in the size of the tanks, and the construction of tanks sufficient to retain the sewage of a city as large as Waterbury for twelve hours or more is very expensive. We had expected that we would have to construct tanks having an area of four acres, but if we find it necessary to lengthen the period very much we will be obliged to increase the tank area."

MR. CAIRNS: "Now in regard to that, I have here some samples of the effluent from the sand filtration No. 3, running at the rate of two hundred thousand gallons a day per acre, which have been in the incubator at a temperature of one hundred degrees since the 17th of January, and you can see it is perfectly clear, having no putrescible matter in it. If you get near enough to it you will discover that it has no odor.

"To produce a non-putrescible effluent. I think that is a statement of the condition which has been met in sewage disposal nine times out of ten. Of course, there are a few cases on large watersheds, like that of the Metropolitan district around Boston, where the effluent from the sewage disposal goes into small streams and then directly into reservoirs allowed to be used as potable water. There, of course, the important element is to get an almost perfect purification, but in general the great problem today is to discharge your sewage into the river in such a condition that it will not produce secondary putrefaction, even in warm weather when the stream is at the lowest, and to expend money, either in the first cost or in the operation, to get a higher quality than that is to waste it.

"I would like to say about these samples that you will find some suspended matter in them. The one at the higher rate especially has gradually gathered quite a little in the month that it has been in the incubator, but if you will smell of it you will discover that there is no odor which would indicate any putrefaction, and that, of course, is all that we need to achieve."

THE PRESIDENT: Gentlemen, you have heard Mr. Cairns' interesting paper, and his comments to us. It is now open for further discussion. I think those who are familiar with the conditions in Waterbury will say that he is working on the right line in order to find a method of treatment which will render the effluent practically non-putrescible. There are some sanitary engineers here, whom I have no doubt will be glad to discuss this further. Mr. Kelly, have you any questions to ask?

MR. KELLY: I have not had an opportunity, Mr. President, to consider the paper very carefully.

A MEMBER: Do you have a system in Waterbury devised to take the surface water in separate sewers or in the same?

MR. CAIRNS: In some parts of the city we have the combined system, and in other parts we have the separate. In a small part of the city we have the separate system.

THE PRESIDENT: So that you have to take care of a large portion of your rainfall at these outlets?

MR. CAIRNS: Yes.

THE PRESIDENT: And at present you discharge your sewers at a number of places into the river wherever it is most convenient?

MR. CAIRNS: Yes.

THE PRESIDENT: And these large conduits you are building are for the purpose of cutting off all these sewers generally which are discharged into the river and bringing them together so as to control the output into the river?

MR. CAIRNS: To get them all together into the one conduit so as to carry it down to the beds.

THE PRESIDENT: You have sewers on both sides of the river?

MR. CAIRNS: Yes; the conduit where these sewers discharge is in the bed of the river, just below it.

THE PRESIDENT: So you merely extend your sewers from the present outlet to the new sewer that you are building in the bed of the river?

MR. CAIRNS: The grade of these sewers was arranged so as to discharge above the bed of the river, but it is now arranged so as to take the sewage under the bed and discharge into this new conduit.

THE PRESIDENT: Do you mean to use those outlets as a means of overflow for your surface water?

MR. CAIRNS: Yes.

THE PRESIDENT: You would be allowed to turn your storm water for that territory into the river, would you not?

MR. CAIRNS: Yes, we will get the sewage, and we will get the first flush of our gutters, and then beyond that, when the sewer fills up, a large part of it will go directly into the stream.

QUESTION: That you are allowed to do?

MR. CAIRNS: Yes.

A MEMBER: Do you have any danger of overflow in doing that?

MR. CAIRNS: No, we probably won't handle at any time more than twice the ordinary sewage flow. We do not expect with the present population that it will ever run more than half full.

A MEMBER: It can do so during a storm, can't it?

MR. CAIRNS: It is not anticipated that it will ever run more than that. That is, the connections between the terminal chambers and the conduits are not large enough to discharge into the conduit more than that quantity. The conduit running full will carry about twenty-seven million gallons.

A MEMBER: I remember down at the bank there was an inverted siphon right across the river there. Is that working all right?

MR. CAIRNS: It was not a siphon. It was just a twenty-four inch gravity conduit laid along the center of the river.

MR. BARNEY: I would like to ask two or three questions of Mr. Cairns as to the acidity of the sewage, and where there would be an excess of that.

MR. CAIRNS: That is being determined by chemical analysis, but for practical purposes I think the best determination has been the operation of the sand filters. We find that we get a sewage there that is not an acid sewage when it arrives at the works, and that we get results with the use of sand and sand beds, showing that there is nothing unusual in that respect.

MR. BARNEY: I understood you to say that there was an excess of nitrite in the effluent tank.

MR. CAIRNS: Yes, we found some. The chemist is studying that matter very carefully now, and trying to make up his mind what is the explanation of that. Of course we do get a great deal of acid. We do not know just how much. We could find out from the mills how much they use, but a part of it only is discharged into the sewers. A large part of it is discharged into the various brooks that they find it convenient to discharge into, so it is not easy to tell what proportion of it does get into the sewage.

MR. KELLOGG: Is the water supply metered?

MR. CAIRNS: We have about 800 meters out of over 5,000 services. All the large consumers are metered, but the residences are not generally.

THE PRESIDENT: As to the matter of sewers that discharge into the main conduit; is the main conduit of such construction that they can discharge laterally, or directly?

MR. CAIRNS: All the old sewers can discharge directly. I think lower down the river we will have to have a siphon, probably at Center street.

THE PRESIDENT: How is the bed of the river, or the flow, does it show any danger of interfering with the laterals or conduit?

MR. CAIRNS: I think the river has very little tendency to lower. It seems to maintain its grade without much change.

THE PRESIDENT: It looks rocky enough. One other point I wanted to ask about, and that is in regard to this double cone sprinkler. I think in Columbus, Ohio, they proposed to use a single cone. It seems to me your double cone would distribute the sewage a great deal more uniformly.

MR. CAIRNS: We inquired about that. They tried a great variety of nozzles out there, but it does not appear that they ever struck this idea.

MR. KELLOGG: Is that double cone your idea?

MR. CAIRNS: I cannot say just who did devise it.

MR. KELLOGG: I never heard of it before.

MR. CAIRNS: I did not get it up. Do you know, Mr. Taylor? Did you devise that, or did Mr. Johnson?

MR. TAYLOR: I was guilty of it.

MR. KELLY: I would like to ask if in case of an epidemic it would be possible to use disinfectants, like chloride of lime, to

such an extent as to seriously affect your bed, or to what extent you could use chloride of lime without injury? I speak of that for the reason that I have had a little experience in connection with a small plant in a place where they had an epidemic of fever, and chloride of lime was used quite extensively, and the result was a complete sterilization of the bed. I would like to ask whether that would be possible in case of an epidemic in a city?

MR. CAIRNS: I would not think so. We get a very large amount of ground water, so that our sewage is very dilute, and I very much doubt if they could throw enough chemicals into the sewage to affect it very much.

MR. FERRY: Has there been any bacteriological examination?

MR. CAIRNS: No, sir; we have not done any work of that sort yet.

MR. FERRY: How long can a sand bed run without cleansing, or haven't you run one long enough to find out?

MR. CAIRNS: It does not have to have any attention, except when winter came on we furrowed the surface.

MR. FERRY: I should suppose that with the passage of the sewage the fine sand would clog up very quickly.

MR. CAIRNS: I think the furrowing is all the attention it needed.

THE PRESIDENT: I understood from your paper that you only needed to treat your sewage during the low flow months. If very dilute, as you say, with ground water, it seems to me that you would not have to make provision for the high flow months.

MR. CAIRNS: That was the order issued by the court, but we, of course, have to keep in mind the possibility of future trouble which will result in an injunction perhaps covering the whole year.

MR. FERRY: Is it necessary to rest your sand filter one day in seven? I should suppose with the small amount of sewage running through there would be air enough drawn down with the water to supply all the oxygen necessary, which would make a continuous filter.

MR. CAIRNS: I do not think that that would be safe to do. What do you think, Mr. Taylor?

MR. TAYLOR: The sprinkled sewage falls upon the top of the broken stone in the beds. In passing through the air the

sewage receives considerable aeration. The sprinkling filters are, however, rested during one day in eight; partly for the convenience of the assistants at the laboratory, as the resting of the plant makes it possible for them to enjoy a day of rest once in eight days, and partly to give an opportunity for the gelatinous coating which grows on the surface of the sprinkling filters to become reduced by the drying action of the sun. This gelatinous coating, which is often a quarter of an inch thick when growing under the sewage spray, reduces to the thickness of tissue paper upon drying. This residue is easily broken up and is gradually washed away through the filter when it is again put into service.

In the sprinkling filter material the voids have not been greatly reduced during the five months of service. The original voids in the broken stone was 47 per cent. of the total volume of the filtering material. At the end of five months service the void space was 38 per cent. The reduction of space within the filter was therefore only 9 per cent. The effluents from the rapid sprinkling filters are somewhat turbid and they carry about 30 parts of suspended matter per million. This suspended matter is material which has been thrown off by the working filters and is not matter which is subject to secondary putrefaction. The effluents have been carefully studied as to stability and tests have been made in which samples have been maintained at a constant temperature of $99\frac{1}{2}$ degrees Fahrenheit, for a period of nearly a month, without obtaining indications of putrefactive changes. Such a test is many times as severe as any natural condition which would arise.

MR. FERRY: Wouldn't this surface growth get down into the tank or work down into the stone?

MR. TAYLOR: No, sir, it appears just on the surface. It is a different sort of growth than that which appears below. The gelatinous growth below the surface is not strongly knit together, but is more like soft jelly, while that on the surface has considerable substance. If you took some of it up in your hand and turned it over, it would look much like one of the large slugs often seen in a damp cellar.

MR. FERRY: Do you scrape that off?

MR. TAYLOR: No, we do not. It disappears to a large extent during the day of rest.

MR. FERRY: This septic tank which you spoke of, is that open?

MR. CAIRNS: They are all three open tanks. Two of them are run as septic tanks, and the other is a sedimentation tank, which we clean out at intervals so as to keep it clear.

MR. BURT: I would like to ask Mr. Cairns if there has been any investigation of any gases that originate from the septic tank that you operate? In that connection I would say that I have recently read of dangerous gases emanating from a septic tank to such an extent as to cause an explosion, and do quite a little damage to the apparatus.

MR. CAIRNS: We have not made much study of the gases. I think in connection with the experiments in London and also at Worcester, they made a very thorough study of the nature and amount of the gas given off by septic tanks. It is well known that gas will generate to the extent of causing an explosion if it is not given a free outlet. At Exeter, in England, they had a very original experiment in connection with an hermetically sealed septic tank. I was very much interested in it when I was there. They had an ordinary street lamp set up on the top of the tank and they amused their visitors by lighting it. It would burn and make a very fair jet. I suppose it is mostly marsh gas. It seemed to burn quite freely.

MR. KELLOGG: Your filters are using broken stone?

MR. CAIRNS: Yes, just ordinary trap rock. We have not tried anything but trap rock.

THE PRESIDENT: In regard to open septic tanks I would like to inquire as to your experience with odors. Are there any offensive odors from open tanks?

MR. CAIRNS: Nothing noticeable as yet in our experiment station. What gas is given off is immediately diluted so much you cannot notice it.

MR. ALDERSON: At what period does that gas begin to form? Does the weather make any difference with it?

MR. CAIRNS: Of course, it has only been operated so far in cold weather. It starts to form a little scum and when there comes a rain it seems to disappear after that. I saw some tanks in Leeds, England, that had a most astonishing crust on. I saw on one of them beautiful green grass growing on the crust a foot high. There were five feet of sewage underneath it chang-

ing all the time. On the other hand, at Birmingham I saw some open septic tanks that did not seem to gather any scum at all. They said there it would show a tendency to gather a little bit, and then there would come a time when there was a change, or when they had a little shower of rain, and it would all disappear. There must be something in the weather to cause it.

MR. JACKSON: Mr. Cairns, in your visit to England did you notice whether they had any electrically operated sprinklers? Was the sewage screened or taken care of by baffle boards or was it so comminuted that it gave no trouble?

MR. CAIRNS: I did not see any electrically operated sprinklers, but the best works have the sewage very carefully screened before it goes into them. That is the best system that I saw working when I was there in 1900. What was really one of the pioneer systems in the line of sprinkling was at a place called Accrington. There they had an exceedingly strong sewage. I never saw anything like it. It was just about a consistency that would flow down the sewer. They said the average consumption of water was about twelve gallons per day per capita, and they had open septic tanks there. The effluent from those tanks was allowed to flow over a weir and drop four or five feet, as a method of aeration, and then it was taken up by a pulsometer and forced up a central standpipe in a bed, and from there it passed out through four arms with openings in the sides, causing them to revolve on the principle of a Barker's mill. They revolved very slowly and all these little streams were spread around. Of course, that served to give still further aeration. The tank was built up above the ground with a brick wall which was laid open, every other brick being left out, with the idea of getting circulation. They took that tremendously strong sewage and got a very fair effluent without using any chemicals or any other treatment than I described. They seemed to think that the use of the pulsometer had something to do with it, but I do not believe that that idea will ever be taken up generally.

MR. BURT: Did I understand you, Mr. Cairns, that this apparatus is all exposed to the weather?

MR. CAIRNS: Yes, sir.

MR. BURT: I wanted to inquire if when the weather is cold it has any effect on the working of it.

MR. CAIRNS: It certainly does have an effect. After a few days of severe cold weather, you will notice a falling off in the efficiency, but there has nothing been shown yet to indicate that we will not be able to operate it successfully during such a winter as this. Last winter the Columbus experiments went on all through the winter and they got a non-putrescible effluent very successfully, I think, with one or two exceptions all through the winter.

MR. FERRY: As I understand it, you will not have to run it in the winter time, anyway.

MR. CAIRNS: At Waterbury, under the present conditions, we will not, but we believe that we could operate it through the winter without covering it and get fairly good results, at any rate good enough for those conditions.

MR. BARNEY: I could give a little experience in that connection with a septic tank put in about three years ago. It has been operated through two winters without any hindrance, and practically about the same effluent has been obtained. I found it advantageous to put a light roof over it. Before that the weather had an effect because the scum would disappear more or less under rainy, stormy days, but with the light roof on the scum, just about all the scum would lie laterally on the top, and there was no gas whatever discharged.

MR. CAIRNS: I suppose it is somewhat more advantageous to have them covered. If you have septic tanks on a large scale the question of covering is a pretty serious one, and I think a good many engineers would rather sacrifice a little efficiency in order to save that expense.

MR. BURT: If heat generates objectionable qualities in the sewage, is there not some process of cooling the sewage, or is there not some process by which that could be done so as to render it less obnoxious? I just merely suggest that.

MR. CAIRNS: I suppose that cooling it would have the effect you describe though I do not believe that is an effect we want to produce. Bacterial action is known to be more vigorous at high temperatures than at low, and the more bacterial action we get the more putrefaction we get.

THE KIMBERLY AVENUE BRIDGES OF NEW HAVEN.

MR. BURT: In the matter of the foundation, I would like to ask Mr. Kelly if he has in the course of his very large experi-

ence known or observed anything of the deteriorating effect upon the concrete about the head of spiles that were driven above the water line?

MR. KELLY: I never observed anything of that kind. I do not know that my attention has been specially directed to concrete about the head of piles. I never saw anything to indicate deterioration. On this work at the Kimberly Avenue bridge I noticed that after the concrete had been exposed to the water for a few months it became covered over with a growth or coating which serves as a protection to the concrete.

A MEMBER: What kind of cement did you use?

MR. KELLY: For the retaining walls and abutments, Dragon cement was used almost entirely. For the piers, Alpha was specified. For the columns, and for the floor slabs, a slow setting cement like the Alpha is required.

MR. WIGGIN: I would like to ask Mr. Kelly what method he used to protect the rear ends of the girders against corrosion. As near as I can read the small plan that is with his paper, the elevation of the bridge seat seems to be about three feet and a half above high water, so that the rear ends of the moving girders will dip into the water when the bridge is opened at high tide.

MR. KELLY: The girders will, at high tide, go into the water a little, but there did not seem to be serious objection to that, at least compared with what was necessary to keep them out of the water. The bridge was raised for this construction about three feet and a half. We would have had to raise it another three feet to keep the counter weight end entirely out of the water at all times, and, of course, to do that the filling necessary across the meadows would be a very serious matter. The counter weight will have the spaces between each weight filled with grout.

MR. WIGGIN: What did you do to protect the structural steel work of the overhanging ends?

MR. KELLY: That was simply painted. Of course, that will need attention. It is something which does not affect the stability of the bridge.

MR. WIGGIN: We have certain bridges on the New York road that are continually dipping into the salt water, and they probably do so more frequently than the Kimberly Avenue bridge

will have to. The preservation of these bridges from the corrosive effects of the salt water has been a troublesome problem and one that is yet unsolved. As an example of the destructive action of the salt water, I would say that about ten years ago we put some 6" $\times$ 4" $\times$ 5/8" angles into one of these bridges. These angles were frequently submerged and about a month ago I visited this bridge. We took out some of these angles, and found that large portions of them had entirely disappeared while the remainder was simply dust.

MR. KELLY: I believe that some one has tried the use of water-tight steel pits to protect the ends of the moving girders on one or two Scherzer bridges. There was something of that kind indicated for this bridge at first, but it was abandoned as not desirable.

MR. WIGGIN: We have in Bridgeport a rolling lift bridge where the ends of the girders drop down to what would be water if we did not provide pits of some kind. These pits are built in a large masonry pier and have given us a good deal of trouble. We have tried all kinds of tricks to keep the water out, and get it out after it got in. These pits are now waterproofed on the inside, so that there is practically no leakage, but they catch a large amount of rain water and have to be pumped out frequently. I consider pits a nuisance and would avoid them if possible.

MR. KELLY: It occurred to me in connection with this work at Kimberly Avenue that it might be possible to remedy that trouble in another way, but it did not appear to be necessary, so it was not done. The use of these steel pits would be quite an obstruction in the waterways. There were those objections which you speak of. It seemed to be less objectionable to let the end down into the water.

MR. BURR: I would like to ask Mr. Wiggin if these pits would be necessary if the ends of the girders were kept thoroughly painted?

MR. WIGGIN: Why, something is necessary, because you could not keep the paint on there if the bridge was frequently opened and the girders wet.

MR. BURR: You mean the salt water would take it off?

MR. WIGGIN: Why, yes. We have tried a great variety of paints upon the bridges I referred to, and none of them have furnished any protection worth mentioning.

A MEMBER: Have you tried crude oil?

MR. WIGGIN: Yes, sir, I think we have. We have tried most everything. We are trying at Westport, on our new lift bridge, something which seems to give as much promise as anything. We haven't found anything yet that works very well in such places. Whether this will or not remains to be seen. It promises well at present. It is known as "Minwax."

MR. BARNEY: What is that you are putting on?

MR. WIGGIN: What is known as "Minwax."

A MEMBER: Is that on a bridge that is in the water a part of the time?

MR. WIGGIN: Which bridge do you refer to?

A MEMBER: The one that you first referred to.

MR. WIGGIN: Yes, it is in the water considerable. We put about 2,000 cars a day over these bridges, and every time a train goes over it, the bridge goes into the water. This bridge that I speak of is a transfer bridge for loading cars on to the car floats, while they are floated from Harlem River to Jersey City. We have four of these bridges at Harlem River and more at Oak Point. While the Oak Point bridges are comparatively new, I think having been put in four or five years ago, we are commencing to see quite serious signs of corrosion already, although we give them the very best care we possibly can.

There is another thing I should like to ask some of the members about. I notice on the parapet for the roadway Mr. Kelly has put in stone-wearing surface, while for the sidewalk he has left the concrete flush with the walk. Now in quite a number of towns where we have been eliminating grade crossings by constructing highway bridges on concrete abutments, there has been considerable discussion about the use of concrete parapets. That is, whether a wide parapet of rich concrete will give satisfactory service when finished off flush with the surface of the roadway. There seems to be quite a difference of opinion scattered along the road as to the durability of that kind of a concrete parapet, and I would like to inquire if Mr. Kelly or any other member has had any experience with parapets of that kind?

MR. KELLY: We have had no direct experience with concrete surfaces for street traffic, but we have had experience with the use of stone parapets. I have put granite into these bridges at

Kimberly avenue. We have used East Haven redstone, which is a very hard stone, and about as hard as you can get in any part of this country next to granite, and that very soon shows wear on the edges. It seems to me that concrete would not give as good results. The cement mortar which cements the mass together is not as hard as the stone and if that is pulverized it would go to pieces more rapidly. For that reason we have used granite coping as the most desirable.

MR. ALDERSON: I put some construction of that kind on to some bridges that has stayed there now for a matter of four or five years, and there is no apparent wear. Simply cracks in the surface, occasionally.

MR. WIGGIN: The point I had in mind was whether it was because of any abrasion on the top of the parapet.

MR. ALDERSON: One of these bridges that I referred to is quite narrow. In fact, that is one of the faults of the design. I cannot find any great wear of it, or any destruction to speak of.

MR. KELLY: What is the traffic over it? Is it like the city traffic?

MR. ALDERSON: No, it is simply suburban traffic. There is no heavy traffic. Not what you would call heavy traffic.

MR. WIGGIN: In some cases we have set the parapet low, and laid the planking over the top of it instead of putting on stone. There seems to be some little feeling among some of the people on the road about putting dressed stone into concrete abutments. They say, "If you are going to use concrete, why not make it all concrete?"

A SPIRAL CURVE FOR STREET RAILWAYS.

MR. RYDER: I would like to ask Mr. Turner to explain a little more at length what his method is with long radius curves where it is desirable to have a long spiral. Suppose it is desirable to put in spirals of more than 200 feet in length. What would be the best way to do it? Would you increase the length of chords to fifty feet or more? Or would you use more than four chords?

MR. TURNER: I do not think that it would be readily adaptable to a spiral over two hundred feet. I think for most street railway work it would not. In case I wished to use a longer spiral

I am inclined to think I would develop the system a little bit further and make it six or eight. I would say that since I took up the writing of the paper I have discovered what I think is a very much simpler form. It is not very difficult to under-

		No. of Chords in Spiral = n									
		1	2	3	4	5	6	7	8	9	10
Position of Chord Point in Spiral = x	1	$\frac{6}{12}$	$\frac{6}{18}$	$\frac{6}{24}$	$\frac{6}{30}$	$\frac{6}{36}$	$\frac{6}{42}$	$\frac{6}{48}$	$\frac{6}{54}$	$\frac{6}{60}$	$\frac{6}{66}$
	2		$\frac{15}{18}$	$\frac{15}{24}$	$\frac{15}{30}$	$\frac{15}{36}$	$\frac{15}{42}$	$\frac{15}{48}$	$\frac{15}{54}$	$\frac{15}{60}$	$\frac{15}{66}$
	3			$\frac{28}{24}$	$\frac{28}{30}$	$\frac{28}{36}$	$\frac{28}{42}$	$\frac{28}{48}$	$\frac{28}{54}$	$\frac{28}{60}$	$\frac{28}{66}$
	4				$\frac{45}{30}$	$\frac{45}{36}$	$\frac{45}{42}$	$\frac{45}{48}$	$\frac{45}{54}$	$\frac{45}{60}$	$\frac{45}{66}$
	5					$\frac{66}{36}$	$\frac{66}{42}$	$\frac{66}{48}$	$\frac{66}{54}$	$\frac{66}{60}$	$\frac{66}{66}$
	6						$\frac{91}{42}$	$\frac{91}{48}$	$\frac{91}{54}$	$\frac{91}{60}$	$\frac{91}{66}$
	7	$dx = \frac{a}{b} D$					$\frac{120}{48}$	$\frac{120}{54}$	$\frac{120}{60}$	$\frac{120}{66}$	
	8	where							$\frac{153}{54}$	$\frac{153}{60}$	$\frac{153}{66}$
	9	$a = 6 + 5(x-1) + 4[1+2+\dots+(x-1)]$ $b = 6(n+1)$								$\frac{190}{60}$	$\frac{190}{66}$
	10	or, $a_n = a(x-1) + 5 + 4(x-1)$									$\frac{231}{66}$

stand, and it can be extended to six or eight chords if you wish. In practice I think the four-chord was usually sufficient.

MR. RYDER: I think it might be of interest to know that for a spiral of any number of chords, it is quite easy to figure out the deflection angles at any point on the curve. The deflection angle for any point on a spiral of any number of chords bears a

simple relation to the deflection angle for one chord on the circular part of the curve. You will notice in Mr. Turner's paper that simple ratios are given for the deflections for every point on a four-chord spiral.

On page 63 is a table giving these ratios for any spiral having not over ten chords— D =deflection angle for one chord on circular part of curve; dx =deflection angle to any chord point x from the p. c. of the curve.

MR. TURNER: I think Mr. Ryder has hit on a general theory. It is my desire to make the number of chords as small as possible consistent with a good curve, or to get good work. It seems to me that that formula would be very useful.

ASH CREEK BRIDGE.

THE PRESIDENT: Gentlemen, Mr. Minor's paper is now open for discussion. Are there any questions to ask?

MR. BURT: I would like to ask Mr. Minor, or anyone who has had experience, whether in that experience they have known of cases where piles have been decomposed or rotted by the action of the concrete over and about the sides of them? I have heard of some such cases where the piles were practically destroyed by the action of the water in destroying the concrete.

THE PRESIDENT: In reply to Mr. Burt's question, so far as I am concerned, I do not know of any case where the concrete has deteriorated the wood, but I have seen where the wood has rotted because it was exposed to the air where the concrete was not carried deep enough, or where the piles were not cut off low enough so as to keep them constantly wet. I have known of instances where the piles were cut off above high water or a little above high water, and the concrete was carried down over the piles perhaps a foot, and the heads of those piles rotted, but I think the reason was found in the fact that the air had access to those piles. I do not know of any reason why concrete should have that effect upon the wood.

MR. JACKSON: I would like to ask Mr. Minor if he thinks it would be feasible to accomplish the same result of the arch by tying the abutments together instead of flattening them out?

MR. MINOR: The weight on top was not very heavy.

MR. JACKSON: But do you think it would be feasible to tie them together?

MR. MINOR: I should hardly advise that. It would be feasible, but it would cost more because that work would be under water.

MR. WEAVER: I notice in Mr. Minor's paper that he speaks about the advantage of putting in riprap. I have just a point in regard to that to bring out which may be interesting. Up at the new Connecticut River bridge that they are building at Saybrook they have tried a new feature. When the place was dredged for the piles to be driven riprap was thrown into the hole before the piling was driven, and the piles were driven down into this riprap. You would never think that it would fill in to them, but it seemed to work out very nicely. Of course, the riprap naturally went down into the mud with the piles, and the result was to make a much more solid foundation than it would to throw the riprap in after the piles were driven. It had a very good effect.

THE PRESIDENT: I understand that the riprap was deposited before the piles were driven and the piles driven through it.

MR. WEAVER: Yes, the holes were filled with riprap and the piles driven down into them. It gave a very much better foundation because the mud is quite deep there and soft.

MR. RYDER: I would like to ask if in that case they got good support at the bottom? If there was a hard bottom?

MR. WEAVER: No, I understand not. I was not engaged on the job and I only saw the work. It is quite deep there, and, as I understand, with a soft mud bottom to a considerable depth. I do not think that they struck any hard bottom.

THE PRESIDENT: It seems to me if the stone were very large that it might interfere with the driving of the piles.

A MEMBER: They were very small stone, as I understand. I do not understand that would amount to anything where you had a good hard bottom.

MR. WEAVER: In this case, where they found very much soft mud, it was feasible and had a good effect.

MR. KELLY: When the piles began to go through the stone, or through this riprap, the resistance on them would be considerable I could see.

MR. WEAVER: I was not on the ground, but I think there are some gentlemen here who have been. I do not know whether Mr. Terry knows about it or not. Mr. Terry, do you know how deep that riprap was?

MR. TERRY: I should say ten or twelve feet. I do not know exactly.

REBUILDING THE HOUSATONIC RIVER BRIDGE AT SANDY HOOK.

THE PRESIDENT: I think Mr. Terry must have performed some acrobatic feats in order to get there and complete this work within such a very small time: to decide upon the design, etc. It seems to me the designing was almost instantaneous, or done the same day.

MR. WIGGIN: It was not a question of aesthetic design but simply a question of getting the construction work started along logical lines at the earliest possible moment. The design was readily determined upon: the principal points to consider being sufficient strength to carry the traffic: suitable openings for ice, etc., during the spring freshets: and a trestle that could be utilized to advantage as falsework for the erection of a permanent steel bridge.

THE PRESIDENT: Any further discussion of Mr. Terry's paper?

I would like to ask Mr. Terry whether they had any ice in the river to contend with?

MR. TERRY: Very fortunately, while we had about three days of cold weather at that time, there was no ice to amount to anything, and it did not interfere with the construction of the bridge proper. After the bridge itself was completed we spent some time in building ice-breakers, which I did not include in my description. We had to do the best we could under the circumstances. It is all complete now, however. We are ready for the ice if it comes. It does not look as if it was coming.

THE PRESIDENT: Any further discussion of this very interesting operation?

A MEMBER: I would like to ask Mr. Terry if this bridge was destroyed before? I think I have heard that it was.

MR. TERRY: Yes, it was destroyed about three years ago: in 1903 or 4, I think. This was the second destruction.

THE PRESIDENT: I would like to ask a question as to the situation in the river. Does the river rise there to an extraordinary height on account of the location? As I recollect, the river is in a sort of a gorge there. Does the water rise very high at times, twenty, thirty or forty feet, or something like that?

MR. TERRY: Oh no, nothing like that.

REINFORCED CONCRETE TANKS.

MR. FERRY: Perhaps I ought to say that the cause of the leak did not arise from any lack of inspection. We knew that no matter how good inspectors we might have on the work, or how careful they might be in overseeing it, if the contractor did not look after it carefully and supply plenty of good material and see that the work was done properly himself, the tank would not be a success; and so we placed the responsibility of the inspection of the structure on the contractor, by specifying that the work would not be accepted until tested.

MR. BURT: I would like to inquire of Mr. Ferry what the maximum pressure was that the tank was subjected to at the point where it began to leak at the bottom?

MR. FERRY: Well, it did not begin to leak at the bottom. That is the strange part of it. The first part of the tank, the lower fifteen feet, did not leak at all. That part of the tank was built in November when it was fairly warm weather, when the temperature was probably somewhere from 35 to 40 degrees, but when we got halfway up with it, we had used up one set of forms so that we had to take the bottom set and move them ahead. That took three or four days, and during the interval the temperature dropped so that when we finished the upper half of the tank the temperature averaged anywhere from ten to thirty degrees above with freezing weather practically all the time. On the first fifteen feet of the tank none of the joints leaked. There was practically no seepage through any of that part of the tank whatever, but on the upper fifteen feet we had all the trouble, and most of the trouble was on the first joint made after the cold weather came on. There was only one theory on which we could account for that leak, and that theory is so full of holes that I do not have very much faith in it. The joint was perfectly tight for two-thirds of the way around the tank, and the leak was continuous for the other third of the way. The only way I could account for it was that in washing off the loose mortar from the joint, and concrete being of course very cold, as we had had cold weather for three or four days, I think possibly a thin film of ice formed on top of the concrete. In putting on the layer of mortar, when it first came from the mixer it was put on warm on that part near where the mortar was dumped on the platform, and that was sufficient to thaw out

the ice; but on the opposite side, when that was put on, the mortar had got cooled off and was not sufficiently warm to thaw the ice, so that there might have been a very thin film remaining where the leaky joint appeared. That theory is not very satisfactory, but it is the most satisfactory one I can think of.

MR. BURT: Was there any apparent difference in the concrete that you placed during the exceedingly cold weather, and the other after spring opened up and before the test was made? Could you detect any substantial difference in it? Did it seem to be about the same as to hardening and firmness?

MR. FERRY: The concrete was all good except the top surface of the roof. The day that the roof was put on the temperature was probably down to ten degrees, or thereabouts, above zero, and the wind was blowing a small gale. We warmed the sand, and the sand was so hot that you could not hold it in your hand, so that when the mortar came up it was warm, but in ten minutes it was crusted over on top. As fast as we spread it we covered it with salt hay and then covered it with boards, and did all we could to protect it. The next spring when we took off the covering there was a thin shell about half an inch thick, over a portion of it that was shelly, and that we took off. Barring that, all the concrete appeared to be good.

I think if we could have built the tank as a monolith, and had the process go on continuously, I do not think we would have had any trouble from leaking at all, because in each section, although there were some leaks where the bolts were, those stopped themselves after a short time. It is shown that the concrete was pretty dense from the fact that where some wet spots appeared, they did not appear on the surface of the concrete for a month or more after the tank was filled. It took a month for the water to get through. It did not go through to run away. You could not see the water coming through, but you could see the wet spot. Take it on a day when the air was dry, the tank would not appear to be leaking at all, but take it when the air was in a nearly saturated condition, there would be little evaporation and the spots would extend nearly to the bottom of the tank on that fifteen-foot stretch. The amount of leakage usually did not amount to very much. The total amount of leakage, after the concrete got well saturated, amounted to only about one-sixteenth of an inch in depth a

day, and that included the evaporation from the surface and whatever came through the side. Of course, there was quite a large surface for water to come through there as the tank was thirty feet high and fifty feet in diameter. That offered a good deal of surface for water to evaporate from.

I question whether concrete can be made absolutely tight in that form of construction. Probably there is seepage through the concrete the best you can make it, and that there would be evaporation from the surface of the tank. I think on the best tank you could build, if it was filled with water, the water would probably leak out in the course of time.

A MEMBER: Could not some of that difficulty have been overcome by using different forms? I should think the only additional cost would be the cost of making the other forms for the outside of the tank.

MR. FERRY: I think if we had had a little different system in making the forms that the forms might have been used over two or three times, but these were made in sections about twenty-five feet long and five feet high, and then they were shifted up bodily.

MR. WIGGIN: I would like to ask Mr. Ferry this: I think he said in the paper that the contract stipulated that the concrete should not be poorer than 1-2-4. I would like to ask if it was made poorer or richer than that?

MR. FERRY: It was actually made 1-2-4, but we did not wish to specify that as just the exact mixture. It was thought better to leave it so that if the contractor did not think that mixture would make it tight he was at liberty to make it just as rich as he had a mind to.

If ever work was honestly done, that piece of work was. The contractor was there nearly all the time, and he had men who had been employed for a year and a half on the filtration plant, so that they were skilled men, and they knew what was wanted, and they took every precaution. I think if they had not had cold weather, or if they had built it monolithic in form, we would have had no trouble at all.

MR. RYDER: I would like to ask a question about the method of splicing the rods, and as to the relative merits of the two methods. Whether or not, where turnbuckles were used, the ends of the rods were upset?

MR. FERRY: Our specifications called for the ends of rods to be upset so that the area at the root of the thread should be a little more than the area of the rod as a whole, but the contractor,—and that was the only place where he skinned on us at all, and it was not his fault either,—sent the rods to a machine shop to have them upset and threaded. But the machinist did not upset them but forged them round and then cut the threads so that the rods of that tank were not as specified. We put in an additional rod at every joint. That is, we had the turnbuckle, and then at every joint we put in an additional rod five or six feet long over the joint so as to have as much metal as we would have had if the rod had been upset. And then in addition to that we took care that no two joints should come near together in adjacent rods. We broke all the joints.

In the other tank where we did not upset the ends of the rods we relied on lapping the ends of the rods at the joints, and both of them stood the test, so I do not know which is the stronger. I presume one is about as good as the other. The lapping of the ends of the rods was a much more convenient way. We found that turnbuckles were a great nuisance in trying to put the rods together.

MR. CHAMBER: How wet was that concrete when you put it in?

MR. FERRY: I could not give the percentage of water that was used, but it was the same as made for the filter beds. When the men were in it they would sink in about halfway up to their knees. Water would flush right to the surface and the concrete required no tamping, only spading along the sides.

MR. CAIRNS: My experience in regard to making tight joints where it was not possible to construct it monolithically, would agree with Mr. Ferry's. I think, however, that there are some objections to it. I do not favor it as an ideal method, but one plan that I pursued certainly made a tight joint. We were constructing a small house on the reservoir, which was to be subjected to about fifteen feet of head pressure water from the outside, and it was necessary to have the structure water-tight, because there are times that the chamber would have to be emptied so that a man could go down into it to work, and we found that we had to have two horizontal joints, and it took three days to construct them. I took sheet lead, strips of sheet

lead about ten inches wide, and as long as I could get, and I stiffened them by tacking them on to narrow strips of wood, putting on the edges occasionally vertical, and then when we were ready to deposit the last batch of concrete we set those on edge and ran the inside of the form about six inches from what would be the outside of the structure, and where the ends came together we lapped them by each other about a foot, so there was room between them for the concrete, and we left about half of that; and then the next day we cleaned the surface thoroughly, got all the dirt off the surface of this material, and put on about half an inch of mortar over the surface, and then proceeded to deposit the concrete. Under that head there was no leakage to the joints. Of course, that method is a little troublesome, and a little expensive too, but I think if it is worth while to go to that much trouble to get an absolutely tight joint it can be gotten in that way.

THE PRESIDENT: Can Mr. Cairns give us any idea about what the actual cost was per cubic foot?

MR. CAIRNS: I could not answer that question, Mr. President. I have not the figures in mind.

MR. FERRY: The fact that comparatively few of the seven or eight hundred feet of joints in this tank leaked was pretty good evidence that that construction can be made tight.

THE PRESIDENT: I think there is no doubt, as Mr. Ferry states, that the trouble on account of the joints was due to cold weather. If it had been finished up before the cold weather came on, I have no doubt it would have been tight.

A MEMBER: If I remember correctly, a method similar to that was used in the reservoir air chamber at that plant in Norwich, where the first plan was to have this chamber in solid rock. It was built but it was found to leak, and then they put in, I think, a concrete lining.



BRADLEY E. HULL.

BRADLEY H. HULL.

In Memoriam.

During the past year our Society has been called upon to mourn the death of an honored member, its first president, Mr. B. H. Hull.

Mr. Hull was born in Ridgefield, Conn., June 25, 1825, and died at Bridgeport, Conn., August 20, 1905, where he had lived for forty-five (45) years.

Mr. Hull was a self-made man and the prominence which he gained as an engineer was largely due to his careful observation and practical experience. His opportunities for gaining a technical education were cut short by the death of his father while he was still young. Having a natural talent for engineering and mechanical pursuits he early learned the trade of millwrighting, which he followed for a number of years. His first experience in engineering was gained in the employ of Henry Smith, County Surveyor of Fairfield County, and while with Mr. Smith he was engaged in the survey and location of the Danbury and Norwalk Railroad, and had charge of a section of this road during its construction. A little later he turned again to mechanical engineering, devoting his attention to the erection and equipment of various water-power plants throughout New England, New York and Pennsylvania. It was during this period of his life that he built an elaborate testing flume for testing turbine water wheels at Windsor Locks in this State. After the completion of this work he opened an office in Bridgeport and devoted his attention to engineering work, more particularly as a specialist in hydraulics. For some years he was consulting engineer for the New Haven and Bridgeport Water Companies, and he served as engineer-in-chief or as a constructing engineer for many of the important water works in the States of Connecticut, Massachusetts and New York, including the A. T. Stewart Company

near Matteawan, N. Y., the Prunell Mills at Oswego, N. Y., the dam for the Glenville Mills at Portchester, N. Y., the dam for the Oneida Company at Wallingford, Conn., and many others. About this time he served for many years as a member of the Board of Engineers for inspection of dams and reservoirs for this State. He did not seek for political honors but was twice elected a member of the Common Council of the City of Bridgeport. He was of a very genial and whole-souled disposition, too generous and unselfish for his own financial interests, of a strong emotional nature, rich in human feeling, a firm and constant friend, of an upright and Christian character; a man of integrity, with few enemies and many friends; a man whose word was as good as his bond.

It was largely due to his enthusiasm and perseverance that the Connecticut Society of Civil Engineers was organized, and he was its first president. To all of its older members he was personally known and highly esteemed, and also to many of the younger; and although during the later years of his life the infirmities of age prevented his attendance at our meetings, his heart and thoughts were always with us and his interest in the welfare and prosperity of the Society was retained until the last

PROCEEDINGS
OF THE
TWENTY-SECOND ANNUAL MEETING
OF THE
Connecticut Society of Civil Engineers
New Haven, Connecticut, February 13 and 14, 1906.

The convention was called to order at North Sheffield Hall, New Haven, at 11.30 A. M., President Albert B. Hill in the chair.

THE PRESIDENT: Gentlemen, will you please come to order? It is time to commence our meeting. The first business is to take up the minutes of the last meeting. Will the Secretary kindly read the minutes of the last meeting?

SECRETARY JACKSON: Mr. President, the minutes of the last meeting have been printed in the annual report. It is not necessary to read them, if we accept them as so printed.

THE PRESIDENT: The minutes of the last meeting are printed in the last report. If there is no objection, the chair will receive a motion to accept the minutes as printed.

MR. KELLOGG: Mr. President, I move that they be accepted.

Motion seconded.

THE PRESIDENT: It is moved and seconded that the minutes of the last meeting be accepted as printed in the last annual report. All those in favor say "Aye." Contrary minds indicate by saying "No." It is a vote.

The time for balloting for the election of officers has expired, and the President will declare the ballot closed. The Chair has appointed Mr. L. W. Burt, of Hartford, and Mr. C. A. Ferry, of New Haven, as tellers to count the ballots. They are now being counted, and the tellers will report in a few minutes.

The next business is the report of the Board of Direction.

The following report of the Board was read by Secretary Jackson:

REPORT OF THE BOARD OF DIRECTION.

A meeting of the Board of Direction was held in North Sheffield Hall, New Haven, on February 14th, 1905, at 10 A. M.

Resignation of Henry R. Souther accepted. Matter of library lists referred to incoming Board of Direction.

Applications for membership received and approved as follows: For active membership, L. W. Robinson, Orson H. Marchant and Edgar S. Duncan. For associate, Frank H. Whiton, H. S. Graves and W. G. Bushnell.

At a meeting held in President Hill's office, New Haven, May 10, 1905, at 2.10 P. M., the resignation of N. F. Heft was accepted, the arrearages in dues of several members considered, and two members dropped.

The matter of library lists was tabled, and the Secretary authorized to have copies of the list printed.

Method of counting ballots tabled. Method of electing members postponed. Secretary requested to make a report at next meeting of the cost of preparing an index. Invitation of Mr. Allen for Society to visit Brooklyn Navy Yard received. Secretary requested to write him thanking him for the invitation, but that the Board did not think it advisable to accept the same at this time.

At a meeting on July 28th in President Hill's office, matter of library lists was tabled. Arrearages of members referred to full Board. One member reinstated. Secretary authorized to have index prepared.

Voted to hold a summer meeting, the arrangements to be in charge of a local committee appointed by the President, and that they be authorized to expend a sum not exceeding fifty dollars.

At a meeting held at Shelton, August 23, 1905, 12.30 P. M., the following names were recommended for membership: D. Schuyler Banta, Hartford, Conn.; George L. Catlin, Bridgeport, Conn.; Ernest A. Keeney, Lyme, Conn.; Elbert E. Lockbridge, Springfield, Mass.; Robert M. Hosley, New Haven, Conn.; Bradford D. Pierce, Jr., Bridgeport, Conn.; George H. Shaw, Hartford, Conn.; Harry W. Storrs, Meriden, Conn.; Charles L. Storum, New Haven, Conn.; Frank M. Smith, Danbury, Conn.; Henry B. Seaman, Stamford, Conn.; James A. Toner, Meriden, Conn.; Emanuel L. Verreen, New Haven, Conn.

At a meeting January 3, 1906, in President Hill's office, at 2 P. M., the arrearages in dues of several members was considered.

It was voted that the matter of library lists be indefinitely postponed.

In relation to the method of counting ballots the Board voted to make the following report to the Society, viz. that they have duly considered the matter, and find that under the constitution they have no right or authority to change the present method of procedure, and that they further report that they do not consider it advisable to suggest any changes in the constitution at this time.

It was further voted: To accept E. B. Soell's resignation; to read letter from American Society of Civil Engineers before annual meeting; index be printed separately, with self covers; that the Constitution and By-laws be printed in each annual proceedings; that the number of indices be left to the Secretary; that the Secretary write Mr. Fitzgerald, thanking him for his address; that the annual meeting be a two-day session, and that it be held at New Haven, and arrangements be left to local committee appointed by the President.

The nominations for officers were canvassed with the following results:

For President—A. B. Hill and W. T. Spencer.

First Vice President—Chas. F. Chase.

Second Vice President—Edward W. Bush.

Secretary and Treasurer—J. Frederick Jackson.

Board of Direction—John K. Punderford and George K. Crandall.

At a meeting held January 11, 1906, in President Hill's office, it was voted to nominate Charles F. Chase and Ernest W. Wiggin for the office of President to fill the vacancies caused by the declinations of A. B. Hill and W. T. Spencer.

Voted to nominate D. S. Brinsmade and Ely M. T. Ryder for the office of First Vice President, to fill the vacancy caused by the declination of Charles F. Chase.

At a meeting of the Board, February 13, 1906, in North Sheffield Hall, resignation of Richmond E. Slade and Arthur A. Adams were accepted and one member was dropped. Following applications for membership were approved: Willis J. Black, Judson M. Minor, Henry L. Bodfish, Edward B. Snell, Walter R. Brown, Isaac M. Story, Wallace W. Burghart, Edwy L. Taylor, Howard E. Bushnell, William C. Watson, George F. Hand, Guilford D. Young, Charles Hatch, Joseph H. Libby.

THE PRESIDENT: Gentlemen, you have heard the report of the Board of Direction. What is your pleasure? Any remarks to be made? Has anybody any motion to make in regard to the disposition of the report of the Board?

SECRETARY JACKSON: I move that it be accepted and printed in the annual proceedings.

Motion seconded.

THE PRESIDENT: It has been moved and seconded that the report of the Board of Direction be accepted and printed in the annual proceedings. All those in favor of that please say "Aye." Contrary minds, "No." It is so voted.

Next in order is the report of the Treasurer, also the report of the Secretary.

REPORT OF THE TREASURER FOR THE YEAR ENDING FEBRUARY 12, 1906.

J. Frederick Jackson, in account with Connecticut Society of Civil Engineers.

RECEIPTS.

To cash on hand February 13, 1905.....	\$905.83
Received from advertisements, 1906	24.00
Received from advertisements, 1905	503.26
Received from back dues	50.00
Received from dues, 1904	93.00
Received from dues, 1905	273.00
Received from dues, 1906	18.00
Received from sale of reports	3.50
Received from sale of dinner tickets	227.00
Total	\$2,097.59

DISBURSEMENTS.

By Carriage	\$ 1.25
Expressage	66.50
Freight	11.42
Expenses annual meeting	265.16
Postage	.45
Printing, stationery and supplies	816.10
Rent, P. O. box	4.00
Engravings	112.50
Services of stenographer	30.00
Stereopticon	9.00
Salary, Secretary	100.00
Summer meeting	124.00
Typewriting	7.08
Telegram to Mrs. R. A. Hull	1.33
Preparing index	20.00
Balance February 12, 1906	528.80
Total	\$2,097.59

THE PRESIDENT: I would say that the accounts of the Treasurer have been audited by a Committee of the Board and found correct.

REPORT OF THE SECRETARY FOR THE YEAR ENDING FEBRUARY 12, 1906.

To the Officers and Members of the Connecticut Society of Civil Engineers:

Your Secretary respectfully submits the following report for the past year:

In May, thirteen hundred copies of the Twenty-first Annual Proceedings were printed and distributed to the members, to those societies with whom we exchange, and to different libraries and institutions of learning. The Society held one additional meeting on August 23d. at New Haven, which was much enjoyed by those present. The Secretary has during the year attended the different meetings of the Board of Direction; has had printed and distributed notices of the different meetings, bills for dues and advertising, and the ballots for nomination and election of officers. By the letter ballot, Mr. Walter T. Spencer and Mr. A. B. Hill received the necessary number of votes for nomination to the office of President. Both declining to stand for election, the Board of Direction filled the vacancies as mentioned in their report. During the year, nineteen new members have been elected, sixteen active and three associate, and one associate refused an election as such. One active member has been transferred to the honorary list, and one honorary member has died.

SUMMARY.

	Feb. 13, 1905.	ADDITIONS.		LOSSES.			Feb. 12, 1906.
		Trans- fers.	Elec- tions.	Death.	Resigned.	Dropped.	
Honorary..	11	1	----	1	----	----	11
Active	237	----	13	----	3	2	246
Associate..	4	----	4	----	1	----	7
Total....	252	----	----	----	----	----	264

The difference in the statement of the membership for Feb. 13, 1905, in the 21st Annual Proceedings and as it appears here, is due to the practice of adding those names to be voted on at the meeting at which the report was read before they actually were elected. This has always caused confusion and was not a true statement of the membership for the date reported.

THE PRESIDENT: Gentlemen, you have heard the reports of the Treasurer and Secretary. Any remarks to be made, or any questions to ask him?

MR. TRACY: I move that the report be accepted as read.

Motion seconded.

THE PRESIDENT: It is moved that the report be accepted as read. Will you have it printed in the annual report?

A MEMBER: Certainly.

THE PRESIDENT: It is moved and seconded that the report of the Secretary and Treasurer be accepted as read and that it be printed in the annual report. All those in favor of that say "Aye." Contrary minds "No." It is so ordered.

Are there any special committees to report? I believe there are none. The next business then in order, according to the by-laws, is the election of new members. Those members all have their names written on the board, as you see. The applications have been canvassed by the Board of Direction, and have been approved by a majority of the Board. How are these gentlemen elected, by ballot?

SECRETARY JACKSON: By ballot unless there is a vote to do otherwise.

THE PRESIDENT: Will you take a ballot?

MR. KELLOGG: I think it should be by ballot and tellers.

THE PRESIDENT: Is it necessary that they should be balloted for separately?

MR. KELLOGG: Mr. President, that has always been a bone of contention in the Society. I think it should be done by ballot. I think the last time that we balloted on candidates it was done singly. I think that is the more favorable way because it gives a chance for individual selection.

SECRETARY JACKSON: It has been the custom to take the names as they came and, unless there was objection, for someone to move that the Secretary cast one ballot for them.

THE PRESIDENT: Then we can follow that plan now. The first name on the list is Willis J. Black.

On motion duly seconded and passed the Secretary was authorized to cast the ballot for the election of Mr. Black.

SECRETARY JACKSON: According to the vote of the Society, I hereby cast one ballot for Mr. Black for membership in this Society.

THE PRESIDENT: Mr. Black is declared elected as a member. The next name is Henry L. Bodfish, of Derby.

On motion duly seconded and passed, the Secretary was authorized to cast a ballot for the election of Mr. Bodfish.

SECRETARY JACKSON: According to the vote of the Society, I cast a ballot for Mr. Bodfish for membership in this Society.

THE PRESIDENT: If there is no objection he will be declared elected.

MR. FORD: Mr. President, it seems to me that this is a waste of time to go through that list in this way. I make a motion that the Secretary be instructed to cast a ballot for all the names on the blackboard that should be voted on, except those two that we have already balloted on.

Motion seconded.

MR. KELLOGG: Mr President, I will say that the name of Walter A. Brown on the board ought to have the middle name written in full, as there is one Walter A. Brown already a member of the Society.

THE PRESIDENT: This is Walter A. Brown.

MR. KELLOGG: But there is a Walter A. Brown already a member. It seems to me that we should have that name written out in full. It appears that way in the application. I request the Secretary to fill out the name in full.

THE PRESIDENT: That is a matter I have no doubt the Secretary will attend to.

Now, gentlemen, it is moved and seconded that the Secretary cast the ballot for the names on the board. All those in favor of that signify by saying "Aye." Contrary minds. It is a vote.

SECRETARY JACKSON: According to the vote of the Society I hereby cast one ballot for the names of Walter A. Brown, Derby; Wallace W. Burghart, Canaan; Howard E. Bushnell, Hartford; George F. Hand, West Haven; Charles Hatch, New Haven; Joseph H. Libbey, New Haven; Judson M. Minor, New Haven; Edward B. Snell, New Haven; Isaac M. Story, New Haven; Edwy L. Taylor, New Haven; William C. Watson, West Haven; Guilford D. Young, West Haven, as members of this Society.

THE PRESIDENT: Gentlemen, we will declare those gentlemen elected. Are there any other members to be proposed?

MR. VERRILL: Something was said at the local meeting about the election of Mr. Scofield to honorary membership.

THE PRESIDENT: Now is the time to bring that up if any one has any name they wish to propose.

MR. VERRILL: If it is proper to propose it now, Mr. President, I would like to propose the name of Mr. Scofield as an honorary member. He is very well known, and has been very prominent in civil engineering. I think it is a proper thing that he should be an honorary member.

MR. BRINSMADE: I think that it is a very good move. I am acquainted with Mr. Scofield, and have been for a good many years. He has had a very honorable career as an engineer about the state. It is unnecessary to say anything to the old members about him, because they know him, but there are some of the younger members of the Society who perhaps should know that for nearly fifty years he has been active in our profession. Soon after the war he was chief engineer of the N. Y., N. H. & H. R. R. Co., and has been very well known for many years as an engineer in Bridgeport, and a member of the Board of Engineers of the state. I take great pleasure in seconding the nomination of Mr. Scofield. It is a nice compliment. I think he is a good man for the Society.

THE PRESIDENT: Mr. Scofield has been nominated for honorary membership. The chair is very happy to hear that nomination, because he is personally acquainted with Mr. Scofield and knows he is a man who will be a great credit to the Society. The chair would state that on the election of honorary members a unanimous vote is necessary. Are there any other remarks to be made?

MR. SPENCER: Mr. President, I would like to ask if Mr. Scofield was ever a member of the Society?

THE PRESIDENT: I could not state positively in regard to that. I have never noticed his name in the catalogue.

MR. SPENCER: I did not know but the Secretary or the older members might know.

THE PRESIDENT: Gentlemen, it has been moved and seconded that Mr. Scofield be elected to honorary membership. All those in favor so indicate. He has the unanimous vote, and is declared elected.

I believe the next thing on the program is the address of the President. That is a matter that can be quickly attended to.

ANNUAL ADDRESS OF PRESIDENT, ALBERT B. HILL.

Gentlemen of the Connecticut Society of Civil Engineers:

On this our twenty-second annual meeting, we have reason for congratulations, that our Society is continually growing stronger in numbers, in the increased interest in its meetings and in the importance and value of the engineering work done by its members.

The science of engineering is advancing rapidly and the engineer is becoming more and more a very essential factor in our country's progress and prosperity.

I say science of engineering, for that is what it is now. Not a great many years ago, the successful engineer was one who used good judgment in applying the forces of nature, but frequently without close analysis of the exact nature of those forces. Now he must use good judgment in utilizing the forces of nature, by exact science methods.

The engineers of the present time are rapidly developing varied and more economical methods of executing engineering projects. The field is very broad, but I will call your attention now to only a few instances.

The development of reinforced concrete construction affords the engineer facilities for solving problems that without a tool of such varied adaptability would be far less practicable and in some cases probably commercially impracticable.

The materials are not new, simply old materials, cement and steel, but greatly improved in quality, cheapened in cost by improved methods of manufacture, and combined in a skillful, scientific manner.

The coefficients of expansion of cement and steel are so nearly alike that these two materials may be safely combined in the same member.

In general, steel of a high elastic limit is the most economical to use, but in many cases mild steel is safer. To increase the efficiency of the steel reinforcement, by mechanical bond, various forms of patented bars have been devised. Each has its special advantages in special cases.

For use in beams, steel about one per cent. of the sectional area of the beam (if medium steel is used) gives fairly good proportions.

Reinforcement must generally be provided for shear; for unless great care is taken to make the concrete a homogeneous monolith, it cannot be depended on to resist heavy shearing stresses; still less can it be depended on to resist tensile stresses. In fact, the best practice does not permit any reliance to be placed on concrete in tension. The reinforcement should be designed to take care of all tensile stresses.

For each member of a structure, it is important that the concrete be deposited continuously until the forms are filled, so as to make a monolith.

A satisfactory finish on the surface of concrete is sometimes a rather troublesome problem, particularly to the architects. A uniform color is the most troublesome feature.

Where the surface is to be exposed to the weather, plastering the surface after the concrete has set (excepting filling holes) should never be permitted.

It is important that forms should be water-tight; then there is no serious difficulty in securing a sound surface, if spading or other well-known devices are properly attended to.

Where a hard dense surface is required, wetting the surface with a thin grout of cement and sand and rubbing thoroughly with a cement brick gives good results, care being taken not to use a very rich grout, unless the surface can be kept wet for a long time.

If a rough surface is desired, axe-hammering or other tooling gives a fine appearing surface, but is more expensive. Scrubbing when the mortar is quite green, to remove the rich surface mortar, gives a rough surface and tends to prevent air cracks, which appear in rich mortar allowed to set in air.

The hair cracks or "crazing," as it is termed, can be avoided in even rich mixtures by keeping the surface wet until crystallization of the cement is completed. It has been found that cement allowed to set in air contracts appreciably, but if the setting takes place under water it expands slightly. Therefore, with rich mixtures, to avoid "crazing," the surface should be kept wet for quite a long time.

It is often stated as a reason for using concrete, that skilled labor is not required. This is true so far as the actual manual labor is concerned; and particularly so for concrete used in foundations, or subject only to compression. But for the more complex structures of reinforced concrete, intelligent, experienced supervision is very important to get the best results.

The enormous quantities of Portland cement of high grade now being used in engineering work shows what a valuable commodity it is proving in facilitating engineering constructions.

The yearly output of the Portland cement mills in this country has increased something like 3,000 per cent. within ten years. The output in this country for 1904 was more than 26,000,000 barrels; and it is estimated that the output for 1905 was more than 30,000,000 barrels.

Another example of wonderfully rapid engineering progress is the development of electric railways.

Many of you can recall when the only street car was the little short horse car, teetering along on the sinuous strap rails laid on wooden stringers; the horse car driver dividing his time between watching the fare box, located at the front end of the car, to which passengers were expected to walk up and deposit their fare, and urging the mule that followed undeviatingly his deeply rutted path between the rails. The only artificial light was the smoky oil lamp; and the heat, if any, a rusty wood or coal stove, frequently either a cherry color or entirely cold—the passengers immediately adjacent to the cherry color roasting, while those at the opposite end of the car were freezing.

When electric railways were first installed, less than a score of years ago, rails weighing 48 to 56 pounds per yard were considered abundantly heavy for any possible electric service. Responding to the demands of an appreciative public, electric cars and equipments have rapidly increased in size, weight, and elegance of equipment, until now on some interurban lines they rival in elegance and speed the steam lines. Rails have increased in weight to keep pace with the equipment. 80 lbs. is quite generally used now for the tee section. Nothing less than 70 lbs. is considered permissible. In cities, as high as 125 lbs. is used and even 137 lbs. in some instances. The rapid increase of weight of rail sections for electrics will be appreciated when we recall that 100 lbs. is the heaviest section used on the N. Y., N. H. & H. R. R.

The improvement in alignment, grade and road bed has been equally rapid. We can all recall how on the early circular curves without transition easements every tangent point could be noted by the lurches the car made in passing into and out of curves.

Now it is imperative that spiral transitions be used; the car passing smoothly into and out of the spiraled curves, so that the beginning and ending cannot be noticed by any movement of the car; the super-elevation of the outer rail being run out on the spiral.

The problems of location of electric lines are somewhat different than with steam lines. On heavy freight steam lines, low grades are of paramount importance. But for electric passenger service, good align-

ment is more important than grade; although grades steeper than five per cent. are to be avoided if possible.

As an evidence of the wonderful development of the electric railway, and its appreciation by the public, we note that more passengers are now being carried by the electric railways of Greater New York than by all the steam railroads in the United States combined.

Notwithstanding the strikingly rapid progress already made in improving electric railways, still greater improvements are bound to come, and are even now beginning to appear on the electric railway horizon.

It is also safe to say that the time is not far distant when the improved electric locomotive, now in sight, will crowd the steam locomotive off its own rails.

Then the pleasure of traveling in well-ventilated cars, free from smoke, soot and cinders, and propelled, lighted and heated by the clean, invisible electric force will be appreciated. And the lines first so equipped will soonest reap the benefits of the public appreciation.

The most recent investigations seem to indicate, that if new lines were to be constructed and new equipment provided, electric locomotives with the systems of multiple-unit and voltage control would be more economical in operation for even the heaviest trains than steam locomotives.

Progress in other departments of engineering work has been evident, perhaps not so rapid as those mentioned, but a steady improvement; for instance, bridge engineering.

The railroad bridge work installed in this state the past year is notable for its solid, substantial character and excellent design.

Much of the highway bridge work shows decided improvement in architectural features. It costs but little more to construct bridges of designs that are pleasing architecturally, as well as statically substantial.

In water supply engineering much good work has been done. The most noticeable improvements towards providing ample supplies of pure water have been made by the private corporations: notably, the New Haven Water Company in providing for filtering its largest supply for the city of New Haven; and the Bridgeport Hydraulic Company in carefully cleaning its new reservoir sites.

The importance to a city of an abundant supply of pure water is beginning to be appreciated.

In the sewerage branch of sanitary engineering progress is being made in the more economical disposal of wastes; to the end that habitations shall be clean and healthful, but without creating nuisances in our freshwater streams. The tendency has been towards developing methods of disposal, that carry the treatment of sewage up to the point only of rendering it non-putrescible.

Where a high degree of purification of the effluent is necessary, no method of treatment has yet been devised that equals the results of intermittent sand filtration.

Where, however, suitable land for filters is difficult of access or otherwise unavailable, and a high degree of purification is not essential,

the method of treatment by septic tanks, sprinkling filters, and settling tanks seems to offer a solution of the problem in special cases, for obtaining a non-putrescible effluent.

I will not take up your time now with the particulars of these various engineering matters, because we expect to have tomorrow a number of interesting papers and discussions by our members, treating of all these different subjects, with the details of special cases.

When we reflect on the rapid progress that has been made during the past fifty years in the engineering art, and realize that in the next fifty years advances are likely to be still greater, we cannot help feeling that we were born too soon. And we may perhaps be pardoned for wishing that we could live a little while in the next century, just to see the wonderfully interesting work that our brother engineers will then be doing.

THE PRESIDENT: Is there any miscellaneous business to be taken up?

SECRETARY JACKSON: Mr. President, there is a communication from the American Society of Civil Engineers which the Board of Direction thought should be read before this meeting of the Society.

THE PRESIDENT: Will the Secretary kindly read it?

The following letter was read by Secretary Jackson:

"OCTOBER 17TH, 1905."

Mr. J. Frederick Jackson,
Sec'y, Conn. Society of Civil Engineers,
New Haven, Conn.

DEAR SIR: It is the hope of the Board of Direction of the American Society of Civil Engineers that its cordial relations with other associations of engineers be maintained, and, if possible, strengthened.

I am therefore directed to say that the Society will always be glad to receive visits from your members; that its reading room and library are open to them and that their presence at any of its professional meetings (which are held at 8:30 P. M., on the first and third Wednesdays of each month, with the exception of July and August) will be most heartily welcome.

Trusting that you will inform the membership of your Society that this is the case, and that we shall have the pleasure of receiving such of them as may find it convenient when in New York, I am,

Yours faithfully,

CHARLES WARREN HUNT, Sec'y."

THE PRESIDENT: Gentlemen, I suppose that it would be the proper thing for the Society to tender a vote of thanks to the American Society of Civil Engineers for their courtesy in sending us this invitation. Is there any motion which you care to make?

MR. KELLOGG: Mr. President, I move to that effect.

Motion seconded.

THE PRESIDENT: It is moved and seconded that the Secretary be requested to send to the American Society of Civil Engineers our thanks for this very courteous invitation and notice. All those in favor of that will signify by saying "Aye." It is not necessary to call for nays. It is a unanimous vote.

Is there any further business, gentlemen? If there is any miscellaneous business, now is the proper time to bring it up while the tellers are counting the votes.

MR. KELLOGG: Mr. President, is the next item after miscellaneous business the election of officers?

THE PRESIDENT: The election of officers then comes in. The tellers, I believe, are not quite ready to report yet. The Secretary is investigating and he will probably report in a moment when the tellers will be ready.

SECRETARY JACKSON: They say they will be ready in about five minutes.

THE PRESIDENT: The tellers will be ready to report in about five minutes. The Chair will take this opportunity to announce that the local members will be glad to entertain the Society at lunch at Heublein's, corner of Church and Court Streets, after this meeting. Somebody will be at the door to see that the members get tickets. This afternoon, as I suppose you are all aware, Mr. Desmond Fitzgerald of Boston will give us a very interesting lecture on "Street Scenes in Manila and Life in the Philippines." He will speak at three o'clock.

At 6:30 tonight the annual dinner and banquet of the Society will be held at Heublein's, the same place where we are going to lunch. I hope as many as possible will be present.

MR. PUNDEFORD: Mr. President, will you pardon me, but the lunch this noon will be upstairs in one of the private rooms and not in the café.

THE PRESIDENT: The members will please bear in mind that Mr. Punderford, chairman of the local committee, reports that the lunch will be upstairs and not in the café down below. It is considered very desirable for the members to be all together if possible. Last year we went down below and mixed in with the regular customers of the place. That, of course, interferes somewhat with our gathering. This time Mr. Punderford has arranged to have it upstairs.

MR. MINOR: Mr. President, would it not be well to announce that the cars on which we are to make the excursion tomorrow afternoon will pass the railroad station?

THE PRESIDENT: Mr. Minor suggests that the members should bear in mind that the cars on which we are to make the trip to the new filtration plant tomorrow afternoon, which have been kindly furnished through the courtesy of General Manager Punderford and the Consolidated Railway Company in going to and returning from the Kimberly Avenue bridge will pass the railway station, so that people who wish to take the trains on their way back can do so.

The Secretary reminds me that there seems to be some misunderstanding about the lunch tickets, and he wishes me to make it clear to

the members that every one is invited to lunch whether they stay to the dinner this evening or not. We wish to have all the members of the Society at the lunch.

Now, gentlemen, please give your attention to the report of the tellers. Mr. Charles A. Ferry then read the following report for the tellers:

Total number of votes cast.....	109
<i>For President:</i>	
Charles F. Chase.....	54
Ernest W. Wiggin.....	53
<i>For First Vice President:</i>	
D. S. Brinsmade.....	65
Ely M. T. Ryder.....	42
<i>For Second Vice President:</i>	
Edward W. Bush.....	96
Scattering	8
<i>For Secretary:</i>	
J. Frederick Jackson.....	107
<i>For Members of the Board of Direction:</i>	
John K. Punderford.....	78
George K. Crandall.....	71
Scattering	5

THE PRESIDENT: Gentlemen, you have heard the report of the tellers. It seems to be a very close vote. Mr. Chase has 54 and Mr. Wiggin has 53. In our Society a plurality elects, but Mr. Chase has a majority also. Mr. Chase is declared elected. (Applause.)

For First Vice President, Mr. D. S. Brinsmade has 65, and is declared elected. (Applause.)

For Second Vice President Mr. Edward W. Bush, having 96, is declared elected. (Applause.)

For Secretary and Treasurer, Mr. J. Frederick Jackson has 107; all the votes cast. (Applause.)

For the Board of Direction there are two to be elected. Mr. John K. Punderford and Mr. George K. Crandall are declared elected.

I congratulate the Society on having elected Mr. Chase President.

MR. CHASE: Mr. President, I suppose I ought to say just a few words. This is a surprise to me. I did not expect that the vote would be so close. It shows the friendly rivalry which has existed between Mr. Wiggin and myself. As the rules of the Society required that the Board of Direction should nominate two candidates, we went into the heat of the canvass under conditions that were entirely friendly. There was the utmost good feeling. I said that I did not want to run against him, and I have no doubt he said the same thing about me. At any rate, gentlemen, I thank you for the honor. This is one of the cases where greatness has been thrust upon me. I will do my best to fill the position to your satisfaction.

THE PRESIDENT: The Chair thinks that it is rather unfortunate that the conditions of the situation mentioned should exist. As Mr. Chase says, if there is a vacancy, it is necessary that the Board should nominate two candidates for the place. I think that the situation might be improved in that respect, and simply make it incumbent upon the Board of Direction to fill the vacancy, but under the circumstances, they had to make two nominations as required by the Constitution.

Is there any further business to come before this business meeting? If there is no further business a motion to adjourn will be in order.

Motion to adjourn duly made, seconded and passed, and the convention declared adjourned until 3 P. M.

AFTERNOON SESSION.

Convention called to order at 3 P. M., President Albert B. Hill in the chair.

THE PRESIDENT: Gentlemen, the distinguished engineer who has so kindly consented to address us this afternoon needs no introduction to engineers. The published tabulated results of his splendid work on the Sudbury watershed of the Metropolitan Water works is regarded much the same by the water works engineers of New England as the Bible was by our Pilgrim Fathers. And when our government needed advice on the Sanitary Engineering problems in the Philippines, it turned to an engineer well equipped to give the advice. We are very fortunate indeed in having the opportunity this afternoon, to not only hear of but see the results of his observations in and about Manila. I congratulate you that you are now to have the pleasure of listening to Mr. Desmond Fitzgerald of Boston.

Mr. Fitzgerald's paper is printed on page 42.

SECRETARY JACKSON: Mr. President, I move that the Connecticut Society of Civil Engineers extend to Mr. Fitzgerald a hearty vote of thanks for this very interesting paper which he has delivered before us this afternoon.

Motion seconded.

THE PRESIDENT: Gentlemen, you hear the motion of Mr. Jackson, to extend a vote of thanks to Mr. Fitzgerald for the elegant lecture he has given us. All those in favor say "Aye." It is a unanimous vote.

Meeting adjourned to 10 A. M., Wednesday, February 14th.

SECOND DAY—MORNING SESSION.

Convention called to order at 10 A. M., President A. B. Hill in the chair.

THE PRESIDENT: The meeting will please come to order. I would suggest, gentlemen, that you all come down and occupy front seats. It will be a little more cosy, and you can hear the speakers a little better.

The first paper on the program this morning is "Sewage Disposal at Waterbury," by Mr. R. A. Cairns. Mr. Cairns needs no introduction. He is one of our past presidents.

MR. CAIRNS: Mr. President and Gentlemen: I am very glad to be here, and have the opportunity to read a description of what we have been trying to do in Waterbury.

Mr. Cairns' paper is printed on page 1.

Discussion will be found on page 49.

THE PRESIDENT: Is there any further discussion of this paper? The time is going on. If not, we will pass to the next paper, "The Kimberly Avenue Bridges of New Haven," by Mr. Cassius W. Kelly, City Engineer.

Mr. Kelly's paper is printed on page 11.

THE PRESIDENT: Is there any discussion on this paper? It is now ready for discussion.

THE PRESIDENT: Is there any further discussion on Mr. Kelly's paper? If not, we will have Mr. Turner's paper on "A Spiral Curve for Street Railways."

Mr. Turner's paper is printed on page 17.

THE PRESIDENT: Mr. Turner's paper is now open for discussion.

THE PRESIDENT: Any further discussion on Mr. Turner's paper? If not, we will pass to the next paper. The next paper is by Mr. Edward E. Minor, "Ash Creek Bridge."

Mr. Minor's paper is printed on page 20.

THE PRESIDENT: If there is no further discussion on that point, we will take up now Mr. Terry's paper on "Rebuilding the Housatonic River Bridge."

MR. TERRY: Before reading the paper I would like to call the attention of the Society to the fact that this bridge was not the Housatonic River bridge at Naugatuck Junction but the Housatonic River bridge at Sandy Hook. The title is perhaps a little incomplete.

Mr. Terry's paper is printed on page 33.

THE PRESIDENT: Will you discuss Mr. Terry's paper?

THE PRESIDENT: Gentlemen, we have another paper by Mr. Ferry, on "Reinforced Concrete Tanks." If Mr. Ferry is ready we will be glad to have it now.

Mr. Ferry's paper is printed on page 26.

THE PRESIDENT: Are there any questions to ask Mr. Ferry in regard to this concrete tank?

THE PRESIDENT: Are there any further questions on this paper of Mr. Ferry's? If not, I think there is a little matter of business left over from yesterday morning's meeting which was not fully attended to.

MR. KELLOGG: Mr. President, with your permission, I would like to offer a resolution that a vote of thanks from this Society be extended to the Governing Board of the Sheffield Scientific School for the use of this room for our meeting.

THE PRESIDENT: Gentlemen, you hear Mr. Kellogg's motion.

Motion seconded and passed.

THE SECRETARY: I would move that a similar vote of thanks be extended to the Consolidated Railway Company for their courtesy in

furnishing us with cars, or that they will furnish to us this afternoon, in which to visit the filtration beds and the Kimberly Avenue bridge.

Motion seconded and passed.

MR. KELLOGG: Mr. President, I do not know whether it is necessary or not, as I hardly understand the by-laws well enough, but I think it is best to have a vote, and that is, that the Secretary's salary be continued the same as last year. It would please me very much to make it more because of the great deal of work involved, and it is increasing every year. At least, I should like to have a motion passed that the salary be continued again as before.

MR. BURT: Second that motion.

THE PRESIDENT: It is moved and seconded that the salary of the Secretary be continued the same as last year. I do not know as it is absolutely necessary for this vote, but it will do no harm. Possibly the by-laws require it. All those in favor, please say "Aye." Contrary minds, "No." It is a vote.

I am sure this Society appreciates the work that has been done by the Secretary. As Brother Kellogg states it is increasing every year, and Mr. Jackson has been very faithful in the work.

MR. CRANDALL: I think that those of us here who have been here through the two days' session, and I notice a number who were here yesterday who are not here today, but those who have been here for two days, certainly must know that a great deal of work has been done by the local committee on arrangements, and certainly the lunch provided by the members yesterday was very fine and should be appreciated by us all. I think the Society ought to pass a vote that the thanks of the Society be extended to the local members, and especially to the committee on arrangements for the very fine preparation they made for this meeting.

MR. BURT: Before that motion is put, Mr. President, I would like to say that I heartily approve of all that Mr. Crandall has said, and would like to add to it, in reference to the dinner, that only a short time ago I attended a dinner where certainly the bill of fare was not superior and the price was a third more. I think the committee on arrangements are certainly entitled to our sincere thanks for all the work that they have done, and the successful showing that they have made.

THE PRESIDENT: It is moved and seconded that a vote of thanks be tendered to the local members, and the committee on arrangements, by the Society. All those who are in favor of the motion signify by saying "Aye." Contrary minds, "No." It is a vote.

THE SECRETARY: There are one or two matters that I would like to bring up at this time. One is in relation to the visit this afternoon to the Kimberly Avenue bridges. It is the request of the American Bridge Company that every man who goes on to the Kimberly Avenue lift bridge this afternoon shall be identified and vouched for by Mr. Kelly or some one in the city engineer's office. They have had some trouble down there, as you know, and are somewhat timid and fear that

possibly something may occur; in order to avoid that, they wish to take every precaution. Therefore, I would request that the members instead of doing as is customary sometimes, separating into small groups, that after visiting the smaller bridge on this side, they keep together and give somebody a chance to get down to the lift bridge ahead of them, so they may be identified, and all troublesome delays avoided and that they may not be subjected to any annoying circumstances.

The other matter is this: It has been customary, of course, for the President to appoint some members who are familiar with the people to furnish the Secretary with details of the careers of those dying. In order that it may be properly presented in the annual report, some account of Mr. B. H. Hull's connection with the Society should be prepared. It will be necessary for the Secretary to have those details, and I would request the President to appoint at this time two members who are qualified to prepare such details, and forward them to the Secretary.

THE PRESIDENT: The Chair would inquire whether that would not be more properly done by the incoming President?

THE SECRETARY: I think not, Mr. President. I think it would properly come within the scope of your authority at present, and it should be done at this meeting.

THE PRESIDENT: I am not quite certain who are most familiar with Mr. Hull. However, I will appoint Mr. Ford, of Bridgeport, and Mr. D. S. Brinsmade, of Derby, as committee on necrology.

MR. BURT: With the permission of the Society I would suggest the addition of Mr. W. B. Palmer, of Bridgeport.

THE PRESIDENT: I will be happy to include Mr. Palmer's name.

Is there any further business? If not, a motion to adjourn will be in order.

Convention adjourned.

SUMMER MEETING.

The annual summer outing of the Connecticut Society of Civil Engineers was held in New Haven, Aug. 23, 1905, everything being run off with that mathematical precision that marks all the actions of the members of the organization, of whom there were about sixty-five present. They left New Haven on a special trolley car at 10 o'clock, the run to Derby being made in the regular time, reaching there at 10.45.

The first work of the party was to inspect the new three-span steel concrete arch bridge that has been constructed over the Naugatuck river by the town of Derby. After having looked at this work, they inspected the work of replacing the old two-span single track trestle over the Housatonic river in Shelton with a new double-track steel riveted three-span bridge. Each of the spans on this bridge is 154 feet long. The work is being done by the Boston Bridge Company for the New Haven railroad, and is one of the contracts let to minor concerns on account of the bridge workers' strike. Four new masonry piers have been erected

and good progress has been made in the steel work. The work is in charge of F. J. Easterbrook, construction engineer for the railroad.

After having inspected this work the members of the party went over to Shelton, where they turned their attention to the Housatonic canal. There is a wooden trestle over this at present, but it is being replaced by one of steel "I" beams on new concrete piers and abutments. This is a very narrow canal and the piers are the narrowest in the state, being only 22 inches wide at the top. They are 160 feet long. The work on them has been done at night and on Sundays, as it was impossible to sink caissons when the factories are at work.

After this inspection had been concluded the members adjourned to a special car that was waiting on a siding, and there had lunch.

At 1 o'clock they returned to the trolley car and were taken down the bank of the Housatonic river to Naugatuck Junction, where six new granite piers and new granite abutments were being constructed for a four-track bridge over the Housatonic river. The work on several of the piers and abutments had been completed. In this work cofferdams and pneumatic caissons were used. The foundations of the piers and abutments are from 15 to 50 feet below high water mark. After this part of the trip had been completed, the members took the trolley back to New Haven, where they held their business meeting and dinner at 5.15 at Savin Rock.

Those to be admitted to membership at the business meeting were: D. Schuyler Banta, Hartford; George L. Catlin, Bridgeport; Ernest A. Keeney, Lyme; Elbert E. Lochbridge, Springfield; Robert M. Hosley, New Haven; Bradford D. Pierce, Jr., Bridgeport; George H. Shaw, Hartford; Harry W. Storrs, Meriden; Curlys L. Slocum, New Haven; Frink M. Smith, Danbury; Henry B. Seaman, Stamford; James A. Toner, Meriden; Emanuel L. Verveer, New Haven.

The committee in charge of the arrangements for this outing was composed of the following members: John K. Punderford, Ely M. T. Ryder, Walter T. Spencer, Ernest W. Wiggin, Charles A. Ferry, Frederick J. Easterbrook, Edward E. Minor, A. William Sperry, Henry J. Kellogg, Henry H. Gladding, J. Frederick Jackson, Albert B. Hill.

CONSTITUTION.

ARTICLE I.

NAME AND OBJECT.

SECTION 1.—The name of this Society shall be the CONNECTICUT SOCIETY OF CIVIL ENGINEERS.

OBJECT.

SEC. 2.—The object of this Society shall be the professional improvement of its members; the encouragement of social intercourse among men of practical science, and the advancement of engineering in its several branches, to wit: Civil, hydraulic, naval, sanitary, mechanical, electrical, architectural, mining, geological, metallurgical, and chemical; the reading and discussion of papers, or to hear lectures on any of the above topics relating to engineering science, and the transaction of all business properly belonging to said Society.

ARTICLE II.

MEMBERSHIP.

SECTION 1.—The membership of this Society shall consist of Members, Honorary Members and Associate Members.

MEMBERS.

SEC. 2.—Members must be at least twenty-one years of age and have had two years' actual experience in some branch of engineering or surveying, or shall have been graduated from an engineering course in a college or university of recognized standing, and they only shall be entitled to vote or transact business for the Society.

HONORARY MEMBERS.

SEC. 3.—Honorary Members may be as many as the Society shall elect. They shall have no vote, nor shall they be eligible to hold office. They shall have the right to attend all public meetings and to enjoy such other privileges as the Society may see fit to grant, excepting, however, such Honorary Members as may be elected from *active membership*, when they shall retain their right to vote and to hold office.

ASSOCIATE MEMBERS.

SEC. 4.—Any person desiring to become associated with this Society, who is not eligible to active membership, may make application, and if said application receives a favorable report from the Board of Direction, it shall be acted upon by the Society at the next regular meeting, and if said candidate shall receive a majority of the votes cast he shall be declared elected as an Associate Member. Associate Members shall have no vote, nor shall they be eligible for any office.

ARTICLE III.

OFFICERS AND THEIR DUTIES.

OFFICERS.

SECTION 1.—The officers of this Society shall be, a President, two Vice Presidents, a Secretary and Treasurer, an Assistant Secretary, and four Directors.

ELECTION OF OFFICERS.

SEC. 2.—The officers, excepting the Assistant Secretary, shall be elected at the annual meeting, and shall hold their respective offices until the final adjournment of the meeting in which others are elected and qualified in their places.

PRESIDENT.

SEC. 3.—The President shall preside at all meetings when present. He shall be chairman of the Board of Direction, and of all standing committees, and shall appoint all special committees, unless otherwise ordered by a vote of the Society.

VICE PRESIDENTS.

SEC. 4.—In the absence or inability of the President to act, the Senior Vice President present shall perform his duties.

SECRETARY.

SEC. 5.—The Secretary shall attend all meetings of the Society, and the Board of Direction, and shall keep the minutes thereof. He shall conduct the general correspondence of the Society, receive communications addressed thereto, and present the same to the proper committees, officers, or meetings. He shall issue notices of all meetings, inform committees of their appointment, and officers and new members of their election. He shall notify all committees of coming meetings and prepare the matters for presentation. He shall keep a complete list of all members, with their addresses and dates of election. He shall publish the annual report. He shall perform such other duties pertaining to his office as may be imposed upon him by the Society or by the Board of Direction, and shall receive a salary to be fixed by the Society.

TREASURER.

SEC. 6.—The Treasurer shall keep the accounts, collect all the funds of the Society and shall deposit the same to the credit of the Society in such depository as may be designated by the Board of Direction. He shall pay all bills, when approved by the President or a majority of the Board of Direction. He shall keep book accounts of his receipts and expenditures, which shall at all times be open to the inspection of the Board. He shall make a duly audited itemized report to the annual meeting. He shall give bonds for the faithful performance of his duties, in such amounts and with such sureties as the Board of Direction may require, and he shall receive such remuneration as the Society may vote to him from time to time. The Board of Direction shall audit the Treasurer's accounts and books annually.

ASSISTANT SECRETARY.

SEC. 7.—The Assistant Secretary shall be appointed annually by the President, and his duties shall be such as would pertain to the office of executive secretary.

BOARD OF DIRECTION.

SEC. 8.—This Board shall consist of the President, the two Vice Presidents, and the four Directors. It shall have supervision and care of all the affairs and property of the Society, and shall conduct the same in accordance with the Constitution and By-Laws. The President or one of the Vice Presidents shall preside at all meetings of the Board, in the order of seniority. In the absence of all these officers, a chairman *pro tem.* may be appointed for the meeting. The first year after this section is adopted, four members shall be chosen at the annual meeting; two shall be chosen for a term of one year and two to serve two years. At all subsequent annual meetings two members shall be chosen to serve two years. Four members shall constitute a quorum to transact business.

ARTICLE IV.

ELECTIONS.

OFFICERS, WHEN ELECTED.

SECTION 1.—At each annual meeting the Society shall elect, by ballot, a President, two Vice Presidents, and a Secretary and Treasurer, to serve one year; also two Directors, to serve two years.

NOMINATIONS, HOW MADE.

SEC. 2.—A nominating blank, containing a list of officers to be voted for, shall be sent by the Secretary to each member, at least sixty (60) days before the day of the annual meeting. The nominations for officers shall be returned to the Secretary in an envelope endorsed with the member's signature, within twenty-one (21) days from the date upon which the blanks were mailed to members, and shall be delivered by him, unopened, to the Board of Direction at a meeting to be held by them to canvass such nominations.

A member nominated for an office by as many as ten (10) other members may become a candidate for that office. If a member be nominated for more than one office, he shall be considered as having been nominated for that office for which he received the most nominating ballots.

If no member receives ten (10) nominating ballots for an office, or if for any reason there should be no candidate for an office, the Board of Direction shall nominate at least two candidates for that office.

All nominees for office shall be notified at once by the Secretary of their nomination and, unless the Secretary receives a prompt declination, it shall be assumed that they have accepted such nomination.

ELECTIONS, HOW CONDUCTED.

SEC. 3.—At least twenty-one (21) days before the annual meeting the Secretary shall send each member a ballot, containing the names (arranged alphabetically) of the candidates for each office. This shall be accompanied by an envelope addressed to the Secretary, with a blank space on the back for the signature of the member voting, also a blank envelope carrying no mark for recognition.

Each member shall signify his choice of candidates on the ballot and return it to the Secretary in two sealed envelopes; the inner one to be left entirely blank, and the outer one endorsed with signature of sender.

Ballots may be sent by mail to the Secretary or handed to him directly. The Secretary shall deliver the ballots, unopened, to the tellers appointed by the presiding officer.

The polls will close at eleven o'clock in the morning of the day of the regular annual business meeting of the Society.

MEMBERS IN ARREARS CANNOT VOTE.

SEC. 4.—It shall be the duty of the Treasurer to furnish the tellers with an alphabetical list of members in arrears for dues for two years or more, and no vote from a member so in arrears shall be counted. Ballots received from such members shall be returned to them unopened with a statement of the reason for such action.

PLURALITY ELECTS.

SEC. 5.—The candidate for each office receiving a plurality of the votes shall be declared elected. In case of a tie vote, the meeting shall proceed to vote by ballot for the candidates who are tied.

NOTIFICATION.

SEC. 6.—The Secretary shall officially notify in writing each officer of his election.

Officers so elected shall qualify and assume their duties immediately after the adjournment of the meeting at which they are elected, and shall hold office until their successors are duly elected and qualified.

VACANCIES.

SEC. 7.—Vacancies occurring for any cause in the list of officers shall be filled by the Board of Direction.

ELECTION OF MEMBERS.

SEC. 8.—Each application shall be announced on the notices for the next meeting after it is received, shall then be considered by the Board of Direction, and, if approved, shall be presented to the Society for ballot at a regular meeting. If a candidate receives a majority of the ballots, he shall be declared elected. In case of rejection, no minute shall be published, but the Secretary shall notify the applicant by letter.

APPLICATION FOR MEMBERSHIP.

SEC. 9.—All applications for membership or for transfer from one grade of membership to another, shall be made on a regular form, to be secured from the Secretary, and to be endorsed by three Members. This form shall contain, immediately over the signature of the applicant, a clause in which the applicant shall agree that if elected he will be governed in all Society matters by the Constitution and By-Laws, and will forward the interests of the Society at all times.

ARTICLE V.

MEETINGS.

ANNUAL MEETING.

SECTION 1.—There shall be a *regular annual meeting* held on the second Tuesday of February each year, at such place as may be selected by the Board of Direction, of which due notice shall be given by the Secretary.

MEETINGS, HOW CALLED.

SEC. 2.—Special meetings may be called by the President and, when so called, notice of the meeting specifying the business thereof shall be mailed by the Secretary to the postoffice address of each member at least ten days before such meeting shall be held. Special meetings shall be called by the President on written application of any ten (10) members.

QUORUM.

SEC. 3.—Ten per cent. of the membership shall constitute a quorum for the transaction of ordinary business, except for the election of officers or for voting on amendments to the Constitution or By-Laws, which shall require fifteen per cent.

ARTICLE VI.

DUES.

SECTION 1.—The annual dues of Members and Associate Members shall be three (\$3.00) dollars per year, payable in advance at the annual meeting.

Members elected at any time of the year shall pay full dues for that year.

SEC. 2.—Honorary Members shall pay no annual dues.

SEC. 3.—The Board of Direction shall have power to remit dues when, in their opinion, it is for the best interest of the Society,

ARTICLE VII.

DEPRIVATION OF MEMBERSHIP.

SECTION 1.—Any member whose dues shall remain unpaid for two (2) years shall be notified by the Treasurer, by sending by registered mail a bill for dues in arrears, on the face of which bill shall be printed the

sections of the Constitution covering such cases. If the dues are not paid within thirty (30) days after such notification, the matter shall be presented to the Board of Direction, who shall have power to drop such member from the roll.

RESIGNATIONS.

SEC. 2.—Resignations must be submitted in writing to the Secretary, and may be accepted by the Board of Direction when all indebtedness to the Society has been discharged.

SEC. 3.—All charges against any member shall be investigated by the Board of Direction before being submitted to the Society.

Any member may be expelled for conduct which may be deemed prejudicial to the Society, by a two-thirds vote of the Members present at a business meeting; provided, that not less than fifteen (15) vote for expulsion, and that such member shall have had one month's notice of the charges preferred against him and of the time appointed for their consideration. All charges must fully set forth the offense or offenses alleged, and must be signed by the members preferring them. An attested copy must be furnished the accused, who shall be entitled to be present and to be heard in defense, in person or by attorney, at all meetings at which the charges are investigated, except during the time when a final vote is being taken.

ARTICLE VIII.

AMENDMENTS TO THE CONSTITUTION.

SECTION 1.—Proposed amendments to this Constitution must be presented in writing at a regular business meeting of the Society, and signed by at least three Members.

Amendments so presented shall be read at the meeting and a copy filed with the Secretary at the same time. At the meeting when presented the proposed amendments may be discussed and amended, but cannot be adopted.

SEC. 2.—At any regular business meeting the amendments previously proposed, according to Section 1, may be voted upon by letter ballot. These ballots shall be sent out with the call for the meeting and shall have the proposed amendment, together with the section of the present Constitution covering the point in question, printed upon the ballot. With the ballot shall also be sent an envelope directed to the Secretary and marked "Ballot on Amendment." The Secretary shall keep these letters unopened and present to the presiding officer all replies received up to the hour of closing the polls. Tellers shall be appointed by the presiding officer, who shall open and count all ballots. The result shall be announced to the meeting by the presiding officer. Two-thirds of the ballots cast will be necessary for the adoption of an amendment.

SEC. 3.—The Board of Direction is authorized to number the Articles and Sections of the Constitution and By-Laws to correspond with any changes that may be made.

BY-LAWS.

MEETINGS.

1. In addition to the regular annual meeting, as provided by the Constitution, the Society shall hold at least one other general meeting, and may hold such other meetings to listen to such lectures or addresses, or to visit engineering works of interest, or of a purely social nature, as the Board of Direction may decide to call.

GENERAL ORDER OF BUSINESS AT ANNUAL MEETING.

2. The following general order of business shall be observed at annual meetings:

1. Presentation of, and action upon, minutes of last meeting.
2. Report of Board of Direction.
3. Report of Secretary.
4. Report of Treasurer.
5. Report of any Special Committees.
6. Election of new members.
7. Election of officers.
8. Address of President.
9. Miscellaneous business.
10. Papers, lectures, or addresses.
11. Adjournment.

BUSINESS MEETINGS—ORDER.

3. The following general order shall be observed at Business Meetings:

1. Presentation of, and action upon, minutes of last meeting.
2. Miscellaneous announcements.
3. Stated business.
4. Adjournment.

4. Contributing Members under the old Constitution shall become Associate Members upon the adoption of the Revised Constitution.

5. Actual personal transportation expenses incurred by the Secretary in attending meetings shall be paid from the Society treasury, upon approval of the President or two members of the Board of Direction.

6. In the election of Honorary Members, a unanimous vote is necessary to elect.

7. The Society may at any time, duly named for the purpose, enact By-Laws for the future guidance, consonant with the Constitution. These By-Laws may be amended or repealed at any meeting, in the call for which meeting a copy of the proposed amendment or addition shall have been printed and sent to each member with the said notice.

PARLIAMENTARY RULES.

8. In all questions arising at any meeting, involving parliamentary rules, not provided for in these By-Laws, Roberts' Rules of Order shall be the governing authority.

VISITORS.

9. Visitors may be admitted to meetings under such rules as the meeting may prescribe.

10. All forms, such as blanks for application for membership, ballots for officers, ballots on amendments to Constitution or By-Laws, and other necessary blanks for the conduct of the business of the Society, shall be prepared by the Secretary and approved by the Board of Direction.

List of Members.

With Addresses and Dates of Election.

Members are particularly requested to inform the Secretary at once of any change in address.

HONORARY MEMBERS.

CHITTENDEN, PROF. RUSSELL H.	April 20, 1901
Dean of Sheffield Scientific School of Yale University, New Haven, Conn.	
CLARK, EDGAR	June, 1887
Putnam, Conn.	
CLARK, JOHN E.	April, 1884
Prof. Mathematics, Emeritus, at Sheffield Scientific School, Yale University, South Terrace, Longmeadow, Mass.	
FITZGERALD, DESMOND	Jan. 8, 1901
Consulting Engineer, Brookline, Mass.	
FROST, GEORGE H.	April, 1884
President Engineering News Publishing Co. New York.	
HADLEY, DR. ARTHUR T.	April 20, 1901
President Yale University, New Haven, Conn.	
HATHAWAY, BENJAMIN F.	Aug. 14, 1900
Stamford, Conn.	
HAYNES, EDWARD C.	Jan. 14, 1890
Danbury, N. H.	
PETTEE, WILLIAM E.	Jan. 10, 1899
Civil Engineer, Salisbury, Conn.	
SCOFIELD, HORACE G.	Feb. 13, 1906
Civil Engineer, Bridgeport, Conn.	
SEYMOUR, WILLIAM O.	Feb. 9, 1904
Railroad Commissioner, Ridgefield, Conn.	
SKINNER, FRANK W.	Jan. 9, 1900
Editorial Staff of the Engineering Record, New York.	

MEMBERS.

ADAMS, JULIUS L.	July 18, 1899
Civil Engineer Hartford, Manchester and Rockville Tramway Co., South Manchester, Conn.	
ALDERSON, ALGERNON B.	Jan. 10, 1899
Town Engineer, West Hartford, Conn.	
AMRHYN, GUSTAVE X.	Feb. 9, 1904
Associate Member, New Haven, Conn.	
AUGUR, EDWIN P.	April, 1884
Civil Engineer and Surveyor, Middletown, Conn.	
AYRES, HENRY W.	Jan. 13, 1885
Hydraulic Engineer, Hartford, Conn.	

BACON, ARTHUR W.	Feb. 9, 1904
Secretary United States Engineering Co., New York.	
BACON, JOHN W.	Jan., 1884
Civil Engineer, Danbury, Conn.	
BANTA, D. SCHUYLER	Aug. 23, 1905
Civil Engineer, Hartford, Conn.	
BARKER, WILLIAM H.	Aug. 10, 1904
Civil Engineer, Hartford, Conn.	
BARNEY, SAMUEL E.	Jan. 9, 1900
Prof. Civil Engineering Sheffield Scientific School, Yale University, New Haven, Conn.	
BEACH, CHARLES EDWARD	Jan. 10, 1893
Civil Engineer, West Hartford, Conn.	
BELDEN, EDGAR T.	Jan. 8, 1901
With Warner-Miller Co., New Haven, Conn.	
BELDEN, CLIFFORD H.	March 30, 1900
Civil Engineer, Hartford, Conn.	
BENNETT, RAYMOND F.	March 30, 1900
W. F. Bennett & Son, Contractors, Portland, Maine.	
BERRIAN, RICHARD M.	Jan. 9, 1900
Engineering Department, N. Y. N. H. & H. R. R. Co., Bridgeport, Conn.	
BERRY, CHARLES H.	Aug. 10, 1904
Civil Engineer, Flatbush, N. Y.	
BISHOP, GEORGE H.	Jan. 13, 1885
Hydraulic Engineer, Middletown, Conn.	
BISSELL, CLINTON T.	Aug. 10, 1904
Civil Engineer, Brooklyn, N. Y.	
BLACK, WILLIS J.	Feb. 13, 1906
Civil Engineer, New Haven, Conn.	
BLAIR, CLARENCE M.	Aug. 10, 1904
Civil Engineer, New Haven, Conn.	
BLAKESLEE, CLARENCE	Jan. 9, 1900
Civil Engineer and Contractor, New Haven, Conn.	
BLATCHLEY, WILLIAM J.	Aug. 10, 1904
Civil Engineer, New Haven, Conn.	
BODFISH, HENRY L.	Feb. 13, 1906
Civil Engineer, Derby, Conn.	
BRADLEY, DANIEL E.	Jan. 9, 1894
President Berlin Construction Co., Berlin, Conn.	
BRETT, THOMAS C.	Aug. 10, 1904
Civil Engineer, New Haven, Conn.	
BRINSMADE, DANIEL E.	April 20, 1901
Secretary and Assistant Engineer Ousatonic Water Co., Shelton, Conn.	
BRINSMADE, D. S.	April, 1884
Engineer Housatonic Water Power Co., Derby, Conn.	
BROWN, CHARLES O.	Jan. 11, 1898
City Engineer, Danbury, Conn.	
BROWN, EDMUND	Jan. 10, 1899
Superintendent and Engineer of Norfolk Water Co., Norfolk, Conn.	
BROWN, WALTER A.	Oct. 11, 1902
First Assistant City Engineer, Springfield, Mass.	

LIST OF MEMBERS.

103

BROWN, WALTER A.	Feb. 13, 1906
Civil Engineer, N. Y., N. H. & H. R. R. Co., Derby, Conn.	
BUCK, HENRY R.	Jan. 10, 1899
Civil Engineer, Hartford, Conn.	
BUDDINGTON, JOHN E.	March 30, 1900
Consulting Engineer and Contractor, New Haven, Conn.	
BUNCE, CHARLES H.	April, 1884
Civil Engineer, Hartford, Conn.	
BURGHART, WALLACE W.	Feb. 13, 1906
Town Engineer, North Canaan, Conn.	
BURT, LUTHER HAROLD	Aug. 14, 1900
Department of Designing Engineer, N. Y. C. & H. R. R., New York.	
BURT, LUTHER W.	Jan. 13, 1885
Civil Engineer and Surveyor, Hartford, Conn.	
BUSCHOR, EMIL CHARLES	Jan. 10, 1899
Civil Engineer and Surveyor, Central Valley, New York.	
BUSH, EDWARD W.	Jan. 10, 1899
Assistant Engineer Conn. River Bridge and Highway District, Hartford, Conn.	
BUSHNELL, HOWARD E.	Feb. 13, 1906
Civil Engineer, Hartford, Conn.	
BUSHNELL, W. G.	Feb. 14, 1905
Associate Member, Westinghouse Electric Co., New Haven, Conn.	
CADWELL, WILLIAM H.	May 31, 1893
Civil Engineer, New Britain, Conn.	
CAHN, ALEXANDER	Jan. 9, 1900
Civil Engineer, New Haven, Conn.	
CAIRNS, ROBERT A.	Aug. 29, 1890
Sanitary and Hydraulic Engineer and City Engineer, Waterbury, Conn.	
CARD, HUBER D.	Oct. 24, 1895
Civil Engineer and Surveyor, Willimantic, Conn.	
CARLISLE, HARRY E.	Jan. 9, 1900
Conduit Engineer, S. N. E. Telephone Co., New Haven, Conn.	
CARTER, RALPH B.	Jan. 14, 1890
Civil Engineer, 26 Courtlandt St., New York.	
CATLIN, GEORGE L.	Aug. 23, 1905
Associate Member, Civil Engineer, Bridgeport, Conn.	
CAUM, FRANK	Aug. 14, 1900
Scranton Railway Co., Scranton, Pa.	
CHANDLER, CHARLES E.	April, 1884
Civil Engineer, Norwich, Conn.	
CHAPMAN, FREDERICK S.	Feb. 10, 1903
Philippine Islands.	
CHASE, CHARLES F.	March 30, 1900
Engineer Berlin Construction Co., New Britain, Conn.	
CHENEY, RICHARD OTIS, JR.	Jan. 9, 1900
Civil Engineer, South Manchester, Conn.	
CLARK, HERBERT G.	July 18, 1899
Engineer of Keney Park, Hartford, Conn.	
CLARK, ROSCOE N.	July 18, 1899
Assistant City Engineer, Hartford, Conn.	

CLARK, VINCENT B.	Feb. 9, 1904
Civil Engineer, Milford, Conn.	
CLARK, WILLIAM S.	July 14, 1890
City Engineer, Meriden, Conn.	
COCHRANE, WILLIAM B.	Jan. 14, 1890
Civil Engineer, Stamford, Conn.	
COE, THEODORE I.	Jan. 9, 1900
Architect, New York.	
COGGESHALL, R. C. P.	June, 1887
Superintendent of Water Works, New Bedford, Mass.	
COLE, CLINTON L.	Feb. 9, 1904
Civil Engineer, Hartford, Conn.	
COLLINS, HARRY C.	July 18, 1899
Berlin Construction Co., Boston, Mass.	
COMSTOCK, LEWIS B.	Aug. 10, 1904
Civil Engineer, Bridgeport, Conn.	
COOLEY, ORRIN F.	Aug. 10, 1904
Civil Engineer, Springfield, Mass.	
CORSON, WILLIAM R. C.	Feb. 10, 1903
Civil Engineer, Hartford, Conn.	
CRANDALL, GEORGE K.	Jan. 11, 1887
City Engineer, New London, Conn.	
CRAWFORD, CHARLES M.	July 18, 1899
Secretary Hartford Paving and Construction Co., Hartford, Conn.	
CRAWFORD, NORMAN McDONALD	July 18, 1899
Consulting Engineer, Hartford, Conn.	
CURTIS, FAYETTE S.	Jan. 9, 1900
Vice President N. Y., N. H. & H. R. R., Boston, Mass.	
CURTIS, THEODORE ALLEN	Aug. 14, 1900
Curtis & Johnson, Hartford, Conn.	
DABOLI, LOREN E.	Jan. 8, 1895
Civil Engineer, New London, Conn.	
DARROW, COURTLAND R.	Jan. 8, 1895
Civil Engineer, New London, Conn.	
DAVIS, ARTHUR L.	July, 18, 1899
Assistant Manager Eastern District and Export, American Bridge Co., 100 Broadway, New York.	
DAVIS, F. IRWIN	Oct. 11, 1902
Architect, Hartford, Conn.	
DePEYSTER, FREDERICK	Sept. 3, 1891
Byxbee-DePeyster Trap Co., Meriden, Conn.	
DEYO, SOLOMON LEF.	Jan. 9, 1900
Chief Engineer New York Rapid Transit Subway Construction Co., New York City, N. Y.	
DeBOIS, AUGUSTUS J.	Jan. 9, 1900
Prof. Civil Engineering Sheffield Scientific School, Yale University, New Haven, Conn.	
DUNCAN, EDGAR T.	Feb. 14, 1905
Civil Engineer, Bloomfield, Conn.	
EASTERBROOK, FREDERICK J.	March 30, 1900
Assistant Engineer N. Y., N. H. & H. R. R. Co., New Haven, Conn.	
EDDY, CHARLES W.	Jan. 9, 1900
Civil Engineer, Waterbury, Conn.	

LIST OF MEMBERS.

105

ELLSWORTH, FREDERICK H.	March 30, 1900
Division Engineer N. Y., N. H. & H. R. R. Co., New Haven, Conn.	
EVERIT, EDW. H.	Oct. 11, 1902
Engineer S. N. E. Telephone Co., New Haven, Conn.	
FARNHAM, CHARLES S.	Feb. 9, 1904
Instructor in Civil Engineering, Sheffield Scientific School, New Haven, Conn.	
FERRY, CHARLES A.	Jan. 9, 1900
Civil Engineer and Surveyor, New Haven, Conn.	
FORBES, HENRY D&B.	April 20, 1901
Civil Engineer, College Hill, Ky.	
FORD, FREDERICK L.	Jan. 12, 1897
City Engineer, Hartford, Conn.	
FORD, THEODORE B.	April 20, 1901
Civil Engineer, Bridgeport, Conn.	
FULTON, WILL H.	Jan. 8, 1901
City Engineer's Office, New Haven, Conn.	
GAGEL, EDWARD	Jan. 9, 1900
Chief Engineer N. Y., N. H. & H. R. R. Co., New Haven, Conn.	
GILLETTE, GEORGE W. F.	Jan. 9, 1900
G. M. Grant Co., New Haven, Conn.	
GLADDING, HENRY H.	Jan. 9, 1900
Assistant City Engineer, New Haven, Conn.	
GOSS, EDWARD O.	Nov. 29, 1890
Assistant Treasurer Scovil Mfg. Co., Waterbury, Conn.	
GRAVES, EDWIN D.	Oct. 25, 1895
Chief Engineer Conn. River Bridge and Highway District, Hartford, Conn.	
GREENWOOD, ALBERT H.	Feb. 9, 1904
With Berlin Construction Co., Berlin, Conn.	
GREGORY, J. LOUIS	Aug. 10, 1904
Civil Engineer, Greenwich, Conn.	
HALE, PERRY T. W.	Feb. 10, 1903
Sup't Middletown Water Works, Middletown, Conn.	
HALL, A. CLARK	Jan. 8, 1901
Hartford Water Department, West Hartford, Conn.	
HAND, GEORGE F.	Feb. 13, 1906
Civil Engineer, West Haven, Conn.	
HARTE, CHARLES R.	Aug. 10, 1904
Civil Engineer, New Haven, Conn.	
HASTINGS, F. B.	Feb. 10, 1903
Associate Member. B. D. Peirce Co., Bridgeport, Conn.	
HATCH, CHARLES	Feb. 13, 1906
Civil Engineer, New Haven, Conn.	
HAWLEY, ARTHUR S.	Feb. 11, 1902
C. W. Blakeslee & Co., New Haven, Conn.	
HAZELTINE, LOUIS R.	Feb. 11, 1902
Architect, 94 State St., New London, Conn.	
HEITMAN, ADRIAN C., JR.	Feb. 10, 1903
Civil Engineer, Fort Terry, N. Y.	
HENDERSON, JOHN T.	July 18, 1899
Draftsman Conn. River Bridge and Highway District, Hartford, Conn.	

HIGGINS, SAMUEL	Aug. 10, 1904
General Manager N. Y., N. H. & H. R. R., New Haven, Conn.	
HILL, ALBERT B.	Jan. 9, 1900
Civil and Consulting Engineer, New Haven, Conn.	
HINE, FRANK E.	April 20, 1901
Fisher's Island, N. Y.	
HOSLEY, ROBERT M.	Aug. 23, 1905
Civil Engineer, New Haven, Conn.	
HOYT, FRANK N.	July 18, 1899
Civil Engineer, State Highway Commissioner's Office, Hartford, Conn.	
HOYT, SAMUEL W., JR.	Feb. 9, 1904
Civil Engineer, South Norwalk, Conn.	
INGERSOLL, C. M., JR.	Jan. 8, 1901
Chief Engineer Department of Bridges, New York City.	
INGRAHAM, EDWARD R.	Feb. 9, 1904
General Agent Conn. Mutual Life Ins. Co., New Haven, Conn.	
JACKSON, J. FREDERICK	Jan. 9, 1900
City Engineer's Office, New Haven, Conn.	
JAMESON, MINOR S.	Feb. 9, 1904
Assistant Engineer, N. Y., N. H. & H. R. R., New Rochelle, N. Y.	
JARVIS, CHARLES M.	April, 1884
Vice President P. & F. Corbin, New Britain, Conn.	
JAYNES, FRANK B.	Feb. 10, 1903
Civil Engineer, Bridgeport, Conn.	
JOHNSON, WILLIAM D.	Aug. 14, 1900
Architect, Hartford, Conn.	
JOHNSON, WILLIAM E.	Nov. 29, 1890
Engineer of Hartford Water Works, West Hartford, Conn.	
JONES, EDWIN J.	Feb. 9, 1904
Civil Engineer, Springfield, Mass.	
JONES, WALTER A.	Feb. 10, 1903
Civil Engineer, New Haven, Conn.	
KEFFY, ERNEST A.	Aug. 23, 1905
Civil Engineer, Lyme, Conn.	
KEHR, HARRY T.	Aug. 10, 1904
Civil Engineer, 350 W. 4th Street, New York.	
KELFH, HERBERT C.	Jan. 9, 1900
Consulting Engineer, 1213 Merton Bldg., New York.	
KELLOGG, HENRY J.	April, 1884
First Assistant City Engineer, New Haven, Conn.	
KELLY, CASSIUS W.	Jan. 9, 1900
City Engineer, New Haven, Conn.	
KIRBY, RICHARD S.	March 30, 1900
Civil Engineer, Port Chester, N. Y.	
KITCHEN, FRANK H.	Jan. 8, 1901
47, Pearl St., Buffalo, N. Y.	
KNIGHT, HERBERT M.	Jan. 9, 1900
Construction Engineer of the Commercial Compressed Air Co., Norwich, Conn.	
LAFORGE, FREDERICK W.	Jan. 13, 1885
U. S. Engineer, Fort Terry, Plum Island, N. Y.	
LANE, JOHN S.	Jan. 8, 1901
John S. Lane & Sons, Meriden, Conn.	

LIST OF MEMBERS.

107

LANE, E. LEROY	Jan. 8, 1901
Contractor, Hingham, Mass.	
LAW, ARTHUR P.	Feb. 9, 1904
Civil Engineer, Bridgeport, Conn.	
LAW, WALTER H.	Aug. 10, 1904
Civil Engineer, Bridgeport, Conn.	
LAWTON, EDWIN F.	March 30, 1900
Superintendent Hartford Electric Light Co., Hartford, Conn.	
LEACH, SMITH S.	Jan. 8, 1901
Major Engineers, U. S. Government, Washington, D. C.	
LEE, EDWIN M.	Feb. 10, 1903
Civil Engineer, Gardner, Mass.	
LEWIS, ROBERT P.	Oct. 24, 1895
Secretary Blake & Johnson, Waterbury, Conn.	
LIBBEY, JOSEPH H.	Feb. 13, 1906
Assistant Electrical Engineer, N. Y., N. H. & H. R. R., New Haven, Conn.	
LOCHRIDGE, ELBERT E.	Aug. 23, 1905
Civil Engineer, Springfield, Mass.	
LOOMIS, FRANK W.	July 18, 1899
Civil Engineer and Surveyor, Hartford, Conn.	
LUTHER, FLAVEL S., JR.	Feb. 9, 1904
President Trinity College, Hartford, Conn.	
MALONEY, DENNIS J.	April, 20, 1901
Superintendent of Buildings, Board of Education, New Haven, Conn.	
MALONEY, FRANK A.	Jan. 9, 1900
City Engineer's Office, New Haven, Conn.	
MANNING, GEORGE E.	Jan. 11, 1898
Civil Engineer, Yantic, Conn.	
MARCHANT, ORSON H.	Feb. 14, 1905
Civil Engineer, New Haven, Conn.	
McKENZIE J. M.	April, 1884
Civil Engineer and Surveyor, Yalesville, Conn.	
McKENZIE, THEODORE H.	April, 1888
Sanitary and Hydraulic Engineer, Southington, Conn.	
McKNIGHT, JOHN T.	May, 31, 1893
City Engineer, Rockville. Residence, Ellington, Conn.	
McLEAN, GEORGE H.	Feb. 9, 1904
Civil Engineer, New Haven, Conn.	
MERRELS, CHARLES W.	Jan. 9, 1900
City Engineer's Office, New Haven, Conn.	
MILLER, GEORGE S.	Aug. 22, 1901
Civil Engineer U. S. Fortification, Fisher's Island, N. Y.	
MINOR, EDWARD E.	Feb. 9, 1904
Civil Engineer, New Haven, Conn.	
MINOR, JUDSON M.	Feb. 13, 1906
City Engineer's Office, New Haven, Conn.	
MINOR, SHELDON E.	Sept. 25, 1886
Civil Engineer, Greenwich, Conn.	
MITCHELL, ROBERT E.	Jan. 9, 1900
Civil Engineer and Surveyor, Willimantic, Conn.	
MOORE, WM. HARLEY	Jan. 9, 1900
Engineer Bridges, N. Y., N. H. & H. R. R., New Haven, Conn.	

MORTON, WALTER S.	Aug. 10, 1904
Civil Engineer, Hartford, Conn. .	
MOSS, ERNEST B.	April 20, 1901
Civil Engineer, H. Wales Lines Co., Meriden, Conn.	
MURPHY, HAROLD T.	Feb. 9, 1904
Civil Engineer, Springfield, Mass.	
MURPHY, JOHN P.	July 18, 1899
City Engineer's Office, Hartford, Conn.	
NASH, PAUL	Jan. 9, 1900
City Engineer and Surveyor, Stamford, Conn.	
NICHOLS, CHARLES H.	Jan. 8, 1901
Consulting Engineer and Engineer of Shell Fish Commission, New Haven, Conn.	
NOBLE, EDWARD J.	Jan. 8, 1901
Hartford, Conn.	
O'CONNOR, DON, Associate Member	Feb. 9, 1904
Hartford, Conn.	
OLDERSHAW, FRANCIS H.	Jan. 8, 1901
City Engineer, New Britain, Conn.	
OLMSTEAD, C. HENRY	July 18, 1899
Civil Engineer and Surveyor, East Hartford, Conn.	
OSBORNE, FRED H.	Jan. 9, 1900
Consolidated Railway Co., New Haven, Conn.	
OWEN, ELIJAH H.	March 30, 1900
Civil Engineer, Chagrin Falls, Ohio.	
PALMER, GEORGE E.	March 30, 1900
Assistant Engineer N. Y., N. H. & H. R. R., West Haven, Conn.	
PALMER, SHEPARD B.	Jan. 8, 1895
Civil Engineer and Surveyor, Norwich, Conn.	
PALMER, WILLIAM B.	Jan. 13, 1885
Civil Engineer and Surveyor, Salem Depot, N. H.	
PARDEE, WILLIAM S., Associate Member	Aug. 10, 1904
New Haven, Conn.	
PARKER, GEORGE A.	July 18, 1899
Superintendent of Keney Park, Hartford, Conn.	
PARSONS, FRED H.	Oct. 11, 1902
Sup't Mulloy, Rexford & Co., Williamsbridge, N. Y.	
PARSONS, HAROLD A.	Aug. 14, 1900
City Engineer, Stamford, Conn.	
PATTON, ARTHUR J.	Sept. 12, 1889
Land Surveyor, Waterbury, Conn.	
PECK, ERMON M.	Jan. 8, 1895
Assistant Engineer Hartford Water Works, West Hartford, Conn.	
PECK, LEON F.	Oct. 11, 1902
Civil Engineer, Greenwich, Conn.	
PENDLETON, CLAUDIUS V.	Aug. 10, 1904
Civil Engineer, Yantic, Conn.	
PENFIELD, GEORGE W.	Jan. 8, 1901
Civil Engineer, New Britain, Conn.	
PHELPS, JAMES W.	Oct. 11, 1902
Landscape Architect, Portchester, N. Y.	
PIERCE, BRADFORD D., JR.	Aug. 23, 1905
Civil Engineer, Bridgeport, Conn.	

PIERCE, WILLIAM B.	Feb. 9, 1904
Civil Engineer, Stamford, Conn.	
PIERSON, STEPHEN C.	Jan. 13, 1885
Civil Engineer and Surveyor, Meriden, Conn.	
PIKE, ROBERT G.	Jan. 8, 1901
Street Commission, Middletown, Conn.	
PIKE, WILLIAM K.	Feb. 9, 1904
Civil Engineer, Danielson, Conn.	
POWELL, MAJOR CHARLES F.	Feb. 10, 1903
U. S. Engineer, New London, Conn.	
PUNDERFORD, JOHN K.	Jan. 9, 1900
General Manager Consolidated Railway Co., New Haven, Conn.	
REYNOLDS, WM. B.	Aug. 14, 1900
Land Surveyor, Waterbury, Conn.	
RICE, ARTHUR W.	April, 1884
President Union Mfg. Co., New Britain, Conn.	
RICHARDS, WALTER H.	March 30, 1900
Engineer of Water and Sewer Departments, New London, Conn.	
RIGHTS, LEWIS D.	Aug. 10, 1904
Civil Engineer, New Haven, Conn.	
ROBINSON, HALBERT G.	Jan. 11, 1898
Civil Engineer and Surveyor, Patten, Maine.	
ROBINSON, LEONI W.	Feb. 14, 1905
Architect, New Haven, Conn.	
ROBINSON, SEYMOUR N.	Feb. 9, 1904
Civil Engineer, Hartford, Conn.	
ROLLINS, ROBERT W.	Jan. 9, 1900
General Manager Hartford Electric Light Co., Hartford, Conn.	
RUNGEE, EDWARD J.	Jan. 8, 1901
Civil Engineer, New Haven, Conn.	
RYDER, ELY M. T.	Jan. 9, 1900
Construction Engineer Consolidated Railway Co., New Haven, Conn.	
SAGE, GEORGE H.	Jan. 8, 1895
Vice President Berlin Construction Co., Berlin, Conn.	
SEAMAN, HENRY B.	Aug. 23, 1905
Civil Engineer, Stamford, Conn.	
SELLARS, PHILIP	Feb. 9, 1904
Civil Engineer, Meriden, Conn.	
SHAUGNESSY, JAMES F.	Feb. 11, 1902
Board of Water Commission, Hartford, Conn.	
SHAW, GEORGE H.	Aug. 23, 1905
Civil Engineer, Hartford, Conn.	
SLOCUM, CURLYS L.	Aug. 23, 1905
Civil Engineer, N. Y., N. H. & H. R. R., New Haven, Conn.	
SMITH, FRINK M.	Aug. 23, 1905
Civil Engineer, N. Y., N. H. & H. R. R., Danbury, Conn.	
SMITH, GEORGE E.	Feb. 9, 1904
Assistant City Engineer, Derby, Conn.	
SMITH, H. HILLIARD	March 30, 1900
Architect, Hartford, Conn.	
SMITH, WILLIAM G.	April, 1884
Civil Engineer and Surveyor, Waterbury, Conn.	
SNELL EDWARD B.	Feb. 13, 1906
Civil Engineer, New Haven, Conn.	

SNELL, HARRY B.	Jan. 8, 1901
Civil Engineer, Brooklyn, N. Y.	
SOEHRENS, JOHN H.	Aug. 10, 1904
Civil Engineer, Bridgeport, Conn.	
SPENCER, NORMAN C.	Jan. 8, 1901
Spencer & Washburn, Civil Engineers, Hartford, Conn.	
SPENCER, WALTER T.	Jan. 9, 1900
Division Engineer, N. Y., N. H. & H. R. R., New Haven, Conn.	
SPERRY, A. WILLIAM	Jan. 9, 1900
Civil Engineer and Surveyor, New Haven, Conn.	
SPERRY, HARTLEY W.	Feb. 9, 1904
Associate Member, Short Beach, Conn.	
STEARNS, ELMER W.	Oct. 11, 1902
Civil Engineer, Berlin, Conn.	
STEFRIING, PAUL	Oct. 11, 1902
Civil Engineer, N. Y., N. H. & H. R. R. Co., Bridgeport, Conn.	
STILES, EDGAR H.	Oct. 11, 1902
Civil Engineer, N. Y., N. H. & H. R. R., Cos Cob, N. Y.	
STODDARD, RAYMOND FRENCH	Jan. 9, 1900
Civil Engineer N. Y., N. H. & H. R. R., Milford, Conn.	
STONE, EDWARD M.	July 18, 1899
Civil Engineer, Hartford, Conn.	
STORRS, HARRY W.	Aug. 23, 1905
Civil Engineer, Meriden, Conn.	
STORY, ISAAC M.	Feb. 13, 1906
Civil Engineer, N. Y., N. H. & H. R. R., New Haven, Conn.	
SULLIVAN, JOHN M.	Aug. 10, 1904
Civil Engineer, N. Y., N. H. & H. R. R., New Haven, Conn.	
TAYLOR, EDWARD T.	Feb. 13, 1906
Civil Engineer, New Haven, Conn.	
TAYLOR, LUCIAN A.	June, 1887
Civil Engineer and Contractor, Boston, Mass.	
TAYLOR, WILLIAM T.	Feb. 9, 1904
Civil Engineer, Hartford, Conn.	
TERREY, ALFRED H.	Feb. 11, 1900
Division Engineer, N. Y., N. H. & H. R. R., New Haven, Conn.	
THOMAS, JAMES B.	Jan. 9, 1900
Civil Engineer and Surveyor, Hartford, Conn.	
THOMAS, JAMES A.	Aug. 23, 1905
Civil Engineer, Associate Member, Conn.	
TRACY, JOHN A.	Jan. 9, 1900
Assistant Professor of Science & Engineering, Yale University, New Haven, Conn.	
TRUMBULL, WALTER S.	June 11, 1898
Civil Engineer, 22 York Ave., New York, N. Y.	
TRUMBULL, JOHN S.	Aug. 10, 1904
Civil Engineer, N. Y., N. H. & H. R. R., New Haven, Conn.	
TUNNAN, ALBERT M.	Aug. 10, 1904
Civil Engineer, Chester, Conn.	
TUNNICHWILL, MAX	Jan. 9, 1900
Assistant Engineer, New Britain, Conn.	

LIST OF MEMBERS.

III

VERRILL, GEORGE E.	Feb. 11, 1902
U. S. Assistant Engineer, New Haven, Conn.	
VERVEER, EMANUEL L.	Aug. 23, 1905
Civil Engineer, New Haven, Conn.	
VORCE, CLARENCE B.	Jan. 10, 1899
John F. Kelly Engineering Co., New York City.	
WADHAMS, JOSEPH P.	Feb. 9, 1904
Civil Engineer, New Haven, Conn.	
WADSWORTH, A. R.	Oct. 27, 1886
Civil Engineer and Surveyor, Farmington, Conn.	
WARD, EDWARD T.	Jan. 9, 1900
Consulting Engineer, Santa Barbara, Cal.	
WARDWELL, FREDERICK S.	Feb. 9, 1904
Civil Engineer, Stamford, Conn.	
WASHBURN, ALBERT L.	Jan. 10, 1899
City Engineer's Office, Hartford, Conn.	
WATSON, WILLIAM C.	Feb. 13, 1906
Civil Engineer, West Haven, Conn.	
WEAVER, HALSEY A.	Jan. 12, 1897
Civil Engineer N. Y., N. H. & H. R. R., Clinton, Conn.	
WELTON, NELSON J.	April, 1884
Civil and Hydraulic Engineer, Waterbury, Conn.	
WHEELER, CHAS. A.	Jan. 8, 1901
Prof. of Mathematics, Conn. Agricultural College, Storrs, Conn.	
WHEELER, FREDERICK I.	Aug. 27, 1901
U. S. Engineer's Office, New London, Conn.	
WHITE, HOWARD E.	Feb. 9, 1904
New Haven Gas Light Co., New Haven, Conn.	
WHITNEY, ELI	March 30, 1900
President New Haven Water Co., New Haven, Conn.	
WHITON, FRANK W.	Feb. 14, 1905
Associate Member, Architect, Hartford, Conn.	
WIGGIN, ERNEST W.	March 30, 1900
Second Assistant Bridge Engineer, N. Y., N. H. & H. R. R., New Haven, Conn.	
WILCOX, RALPH M.	Jan. 8, 1901
City Engineer, Middletown, Conn.	
WILKES, J. K.	April, 1884
City Engineer, New Rochelle, New York.	
WOLCOTT, HENRY A.	July 18, 1899
Mechanical and Civil Engineer, Hartford, Conn.	
WOOD, CHAS. N.	Aug. 14, 1900
Civil Engineer, Norwalk, Conn.	
YOUNG, GUILFORD D.	Feb. 13, 1906
Civil Engineer, West Haven, Conn.	

ALPHABETICAL LIST OF ADVERTISERS

Name	Business	Page
Alpha Portland Cement Co.	Cement	2
Alsen Portland Cement Co.	Cement	4
American Pipe Manufacturing Co., The	Cast Iron Pipe and Contractors	3
American Sewer Pipe Co., The	Vitrified Sewer Pipe	5
Atlas Portland Cement Co.	Cement	6
Balf Co., The Edward	Teaming and Contracting	31
Berger, C. L. & Sons	Engineering Instruments	33
Berlin Construction Co., The	Steel Structures	(back cover)
Blakeslee, C. W. & Sons	Contractors	43
Brodie Co., The William H.	Steel Rolling Doors, etc.	7
Buffalo Steam Roller Co.	Road Rollers, etc.	8
Connecticut Trap Rock Quarries, The	Trap Rock	32
Consolidated Rosendale Cement Co., The	Rosendale Cement	(inside front cover)
Contractors' Supply & Equipment Co., The	Concrete Mixers	33
Detroit Graphite Manufacturing Co., The	Paint	11
Dixon Crucible Co., The Joseph	Paint	9
Eastern Expanded Metal Co., The	Expanded Metal	14
East Ohio Sewer Pipe Co., The	Vitrified Sewer Pipe	30
Eddy, George M. & Co.	Tapes	13
Edson Manufacturing Co., The	Pumps	12
Engineering News, The	Magazine	17
Engineering Record, The	Magazine	27
Grant, C. L.	Horings	13
Gurley, W. & L. E.	Engineering Instruments	(inside back cover)
Harrington, Robinson & Co.	Rails	10
Hartford Paving & Construction Co., The	Pavements and Concrete	15
Hendricks Co., S. E.	Commercial Register	16
Hering, Rudolf, and Fuller, Geo. W.	Hydraulic and Sanitary Engineers	17
Higgins, Charles M. & Co.	Drawing Inks	22
Kearns, W. F. & Co.	Concrete Steel and Fireproofing	17
Keenan, D. F.	Crushed Stone	10
Keuffel & Esser Co.	Engineering Instruments, etc.	34
Kolesch & Co.	Engineering Instruments	32
Lesley & Trinkle	Giant Portland Cement	18
Lines Co., The H. Wales	Sewer Pipe, Stone and Cement	20
Lorain Steel Co., The	Rails	24
Ludlow Valve Manufacturing Co., The	Gate Valves	23
Lufkin Rule Co., The	Tapes and Rules	22
Municipal Engineering & Contracting Co., The	Concrete Mixers	21
New York Brick & Paving Co., The	Vitrified Paving Brick	25
Pacific Flush Tank Co., The	Miller Automatic Siphon	41
Poole Engineering & Machine Co., The	Heavy Machinery	26
Rail Joint Co., The	Rail Joints	27
Russell Contracting Co.	Contractors	28
Scherzer Rolling Lift Bridge Co., The	Lift Bridges	20
Sessions Foundry Co., The	Sewer Castings, etc.	26
Soltmann, E. G.	Drawing Materials	32
Stevens Sons Co., The H.	Vitrified Sewer Pipe	33
St. Marys Sewer Pipe Co.	Vitrified Sewer Pipe	38
Stoddard-Brown Co., The	Engraving	22
United Building Material Co.	See Lesley & Trinkle	18
Tuttle, Morehouse & Taylor Co., The	Printers and Publishers	42
Warner-Miller Co., The	Cement, Blue Stone, Sewer Pipe, etc.	40
Warren Brothers Co., The	Bitulithic Pavement	44
Warren Foundry & Machine Co., The	Cast Iron Pipe	31
Watson & Jackson	Cement, Granite, Blue Stone, etc.	35
Westinghouse Traction Brake Co., The	Air Brakes	36
Westinghouse Electric Manufacturing Co., The	Generators and Motors	37
Whitehall Portland Cement Co., The	Cement	30

CLASSIFIED LIST OF ADVERTISERS

BLUE PRINTS.	
E. G. Soltmann	32
Keuffel & Esser Co.	34
BORINGS.	
C. L. Grant	13
BRAKES.	
Westinghouse Traction Brake Co.	36
BRICK.	
New York Brick & Paving Co.	25
Warner-Miller Co.	40
BRIDGES.	
Berlin Construction Co.	(back cover)
Scherzer Rolling Lift Bridge Co.	29
CAST IRON PIPE.	
American Pipe Manufacturing Co.	3
H. Stevens Son's Co.	33
Warren Foundry & Machine Co.	31
CEMENT.	
Atlas Portland Cement Co.	6
Alpha Portland Cement Co.	2
Alsen Portland Cement Co.	4
Consolidated Rosendale Cement Co.	(inside front cover)
Whitehall Portland Cement Co.	30
Watson & Jackson	35
Warner-Miller Co.	40
Lesley & Trinkle.	18
CONCRETE.	
Hartford Paving & Construction Co.	15
W. F. Kearns & Co.	17
Russell Contracting Co.	28
CONCRETE MIXERS.	
Contractor's Supply & Equipment Co.	33
Municipal Engineering & Contracting Co.	21
CONTRACTORS.	
C. W. Blakeslee & Sons	43
Russell Contracting Co.	28
American Pipe Manufacturing Co.	3
Edward Balf Co.	31
H. Wales Lines Co.	20
Crushed Stone Connecticut Trap Rock Quarries, D. F. Keenan.....	19
DRAWING MATERIALS.	
W. & L. E. Gurley	(inside back cover)
Keuffel & Esser	34
E. G. Soltmann	32
Charles M. Higgins & Co.	22
ELECTRICAL SUPPLIES.	
Westinghouse Electrical Manufacturing Co.	37
ENGINEERS' AND SURVEYORS' INSTRUMENTS.	
C. L. Berger & Sons.....	33
George M. Eddy & Co.	13
W. & L. E. Gurley	(inside back cover)
Keuffel & Esser Co.	34
Kolesch & Co.	32
Lufkin Rule Co.	22
ENGINEERING MAGAZINES.	
The Engineering News	17
The Engineering Record	27
ENGRAVING.	
The Stoddard-Brown Co.....	22

EXPANDED METAL.	
Eastern Expanded Metal Co.	14
Warner-Miller Co.	40
FIRE PROOFING.	
W. F. Kearns & Co.	17
FLUSH TANKS.	
Pacific Flush Tank Co.	41
MACHINERY.	
Poole Engineering & Machine Co.	26
MOTORS.	
Westinghouse Electric Manufacturing Co.	37
PAINT.	
Detroit Graphite Manufacturing Co.	11
Joseph Dixon Crucible Co.	9
PAVEMENTS.	
Hartford Paving & Construction Co.	15
Warren Bros. Co.	42
PRINTERS AND PUBLISHERS.	
The Tuttle, Morehouse & Taylor Co.	42
S. E. Hendricks Co.	16
PUMPS.	
Edson Manufacturing Co.	12
RAILS AND RAIL JOINTS.	
Harrington, Robinson & Co.	10
Lorain Steel Co.	24
Rail Joint Co.	27
ROAD ROLLERS.	
Buffalo Steam Roller Co.	8
SANITARY ENGINEERS.	
Rudolph Hering & George W. Fuller	17
SEWER CASTINGS.	
Sessions Foundry Co.	26
SEWER PIPES.	
American Sewer Pipe Co.	5
East Ohio Sewer Pipe Co.	39
St. Marys Sewer Pipe Co.	38
H. Steven's Sons Co.	33
H. Wales Lines Co.	20
Warner-Miller Co.	40
STEEL DOORS.	
William H. Brodie Co.	7
STONE (Blue & Granite)	
Watson & Jackson	35
Warner-Miller Co.	40
H. Wales Lines Co.	20
TAPES.	
C. L. Berger & Sons.	33
George M. Eddy & Co.	13
W. & L. E. Gurley	(inside back cover)
Keuffel & Esser Co.	34
Kolesch & Co.	32
Lufkin Rule Co.	22
E. G. Soltmann	32
VALVES AND HYDRANTS.	
Ludlow Valve Manufacturing Co.	23

THESE Proceedings reach some 2500 engineers and contractors throughout the country. No like publication that we know of provides the same amount of advertising for so small an expenditure.

For rates and space, address

J. FREDERICK JACKSON,

Secretary, New Haven, Conn.

DO NOT FORGET OUR ADVERTISERS

THEY ARE ALL FIRST CLASS AND RELIABLE

PATRONIZE THOSE WHO PATRONIZE US

Please Mention this Publication in Addressing Them

Alpha Portland Cement

**THE CEMENT THAT
MADE AMERICAN
PORTLAND FAMOUS**

Alpha Portland Cement Co.

NEW ENGLAND DEPARTMENT

521 and 522 Board of Trade Building

BOSTON, MASS.

F. N. KINNEY, Manager

JOSEPH S. KEEN, JR.
President and General Manager

H. BAYARD HODGE
Secretary and Asst. Treasurer

GEORGE M. BUNTING
Vice President and Treasurer

WM. H. ROTH
Assistant Secretary

The American Pipe Manufacturing Company

Engineers and Contractors for Water Works

No. 112 NORTH BROAD ST.

PHILADELPHIA

J. W. LEDOUX, M. AM. SOC. C. E.
Chief Engineer

JAMES H. DAWES
Supt. of Construction

HAROLD PEROT KEEN
Supt. Operating Dept.

AMERICAN AND GERMAN

BEST MANUFACTURERS OF HIGH GRADE
ID IN THE WORLD. EXTRA QUALITY ALWAYS

ALSEN

NEW YORK GERMAN

THE SIDEWALK CEMENT

EVERY barrel of ALSEN's guaranteed to exceed "Standard Specifications," adopted by A. S. C. E., A. S. T. M., A. R. E., etc. A medium slow set cement has proven in practical tests, in all countries, most **durable** and **safe**.

Forced strength, like forced growth, is **dangerous** to ultimate results.

We supply **QUICK SET**, however, to special order
for special work.

ALSEN's is the **SAFEST** cement manufactured,
as **ANALYSES** prove.

Every barrel passes boiling test before shipped.
Every barrel is matured.

The **Panama Canal** award by Isthmian Commission, the 70,000 bbl. City of Rochester contract, the Key West extension, and many works of nearly equal importance, without a single rejection under most exhaustive tests, substantiate every assertion made for this Portland "**Cement Insurance.**"

WRITE FOR PRICES
TO
American Sewer Pipe Company
PITTSBURG, PA.

Largest Manufacturers of Sewer Pipe in the
World, having FACTORIES located in
FIVE STATES, with the very
best Shipping Facilities

MANUFACTURERS OF

"STANDARD AKRON"
"OHIO RIVER VITRIFIED"
"GRANITE"

SEWER PIPE

Flue Lining Wall Coping
Agricultural Drain Tile
Fire Clay Fire Brick Paving Brick
Porter Blocks
and all Clay Products

We make a specialty of 27-in., 30-in., 33-in., 36-in.,
Standard and Double Strength Pipe
for Water Conduits and Culverts

THE STANDARD AMERICAN BRAND



ATLAS PORTLAND CEMENT

ALWAYS UNIFORM

Output for 1906, over 12,000,000 barrels

Specified by all leading Architects and Engineers throughout the country

The Atlas Portland Cement Co.

30 Broad Street New York

Send for New Book on Concrete Construction

THE KINNEAR STEEL ROLLING DOORS

AS ADAPTED TO CAR BARNS

*The most effective door for this purpose on the market, as well as for
Factory Buildings, Freight Sheds, Mills, Power Plants, Round
Houses, Store Fronts, Stables, Etc.*

IN USE BY

Pennsylvania
R. R.

New York &
New Haven

New York
Central

Long Island
R. R.

Erie R. R.

Lehigh Valley
R. R.

Central of
New Jersey

Delaware &
Lackawanna

and others



IN USE BY

Manhattan
Elevated

Metropolitan
Street R. R.

Brooklyn
Heights R. R.

Interurban
Street R. R.

Hartford
Street R. R.

North Jersey
Str't R.R. Co.

Mohawk
Valley R. R.

Fonda
Johnstown &
Gloversville

and others

WRITE FOR CATALOGUE

WILLIAM H. BRODIE COMPANY

45 Vesey Street

New York City

BUFFALO PITTS



Asphalt Rollers Macadam Rollers Tandem Rollers
Combination Rollers Golf Rollers

BUFFALO PITTS IMPROVED SCARIFIER

This machine has an extended tooth bar outside the main frame. It will cut closer to the curb without shifting the axle than any other make. For further information write for our catalog.



Made heavy, strong and durable.
Notice the heavy brace from main frame to leading wheel.

BUFFALO STEAM ROLLER COMPANY

EASTERN OFFICES

15 Court Square, Boston
150 Nassau St., New York

BUFFALO, N. Y.

Write for Catalogue



¶ An illustrated folder in duo-tone, showing the four colors of Dixon's Silica-Graphite Paint, with practical suggestions for construction and maintenance painting of steel and iron.

¶ The folder will be sent to all interested in good paint and good painting.

JOSEPH DIXON CRUCIBLE CO.
JERSEY CITY, U. S. A.

H. A. NEALLEY, New England Representative
101 TREMONT STREET, BOSTON, MASS.

Wm. Wharton Jr. & Company,

—INCORPORATED—

PHILADELPHIA, PA.

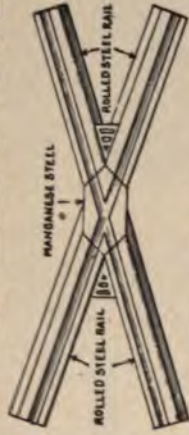
MANGANESE STEEL

THE ONLY MAKERS

—OF—

MANGANESE STEEL

Special Work.



THE BEST IN THE MARKET.

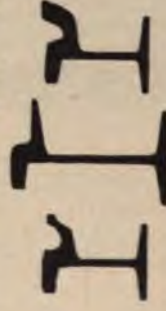
POSITIVELY
THE

Longest Wearing

CONSEQUENTLY
THE

Cheapest to Buy.

Rails and



Fastenings

New England Representatives: **Harrington, Robinson & Co.**

272-276 FRANKLIN ST., BOSTON, MASS.

Splice Bars, Track Bolts, Spikes, Trolley Brackets and Iron Trolley Poles. Designers and Builders STEEL BRIDGES. Roof Trusses and Steel Construction for Car Barns,

Power Houses, etc.

TO Engineers, Architects, Manufacturers and others interested
in the preservation of Iron or Steel Structures from Corrosion

We will cheerfully furnish upon application an illustrated
Book, Showing Bridges and Buildings on which

Superior Graphite Paint

has been used

Interesting Tests and References are also given

It is hoped that prospective users of paint, not familiar with
this product, will investigate its merits before purchasing.
It is particularly adapted to withstand severe conditions.

Immediate Shipments made from Local Stock

Used on many bridges and buildings in Connecticut, to
which we would be glad to refer

Detroit Graphite Manufacturing Company

F. W. DAVIS, Jr., General Sales Agent

141 Broadway, New York 1117 Tremont Bldg., Boston, Mass.



**Lift and Force Pump,
Nos. 8 and 10**



Trench Pump, Nos. 2, 3 and 4

EDSON PUMPS

Edson Diaphragm Pumps are used all over the world for raising large quantities of water full of gravel, sewage, etc., by hand-power.

The Trench Pumps are in use by fully twenty-five per cent. of the railroads and water works in the United States, and by a large proportion of the excavating contractors. This is an open discharge pump, made in three sizes.

The Lift and Force Pumps, also made in three sizes, used by prospectors and miners, for deep trench work, odorless excavating, pile sinking, and for forcing cement into quicksands, are well worthy of your consideration.

Edson Pumps are portable and non-chokable, pumping anything liquid enough to flow.

Send for booklets telling what they have done for others.

EDSON MANUFACTURING CO.

250 Atlantic Avenue

-

Boston, Mass.

ESTABLISHED 1859

GEORGE M. EDDY & CO.

345 to 353 Classon Avenue, Brooklyn, N. Y.



**COTTON TAPES
LINEN TAPES
STEEL TAPES**

Pioneers of the Tape Manufacturing Business in America

And the only firm giving its whole time and entire attention to the
manufacture of tape measures

Test Borings==Exact Samples

CORE DRILL BORINGS FOUNDATION TESTS

FOUNDATIONS FOR HEAVY ENGINEERING STRUCTURES INVESTIGATED

Samples of all materials penetrated saved for record and inspection. Samples of sand, gravel, quicksand, clay, hardpan, etc., shown in same condition as it is from where it is taken.

CORE SAMPLES FROM ROCK

Samples from various strata of rock encountered for investigating the nature and extent of rock in new quarries, mines, etc. The actual stone is brought up for inspection.

**Artesian Wells, Wind Mills, Pumps, Drilling Machinery, Well Supplies
Elevated Tanks for Sprinkler System of Fire Protection**

C. L. GRANT

58 Belden St., Hartford, Conn.

17 Byron St., Providence, R. I.

GEORGE P. BULLARD
President and Treasurer
GEORGE TAYLOR
General Manager

WM. M. BAILEY
Chief Engineer
CHESTER J. HOQUE
Constructing Engineer

EXPANDED METAL

**THE APPROVED FORM OF STEEL
REINFORCEMENT FOR ALL KINDS
OF CONCRETE STRUCTURES, SUCH
AS SEWERS, BRIDGES, DAMS,
RETAINING WALLS, FOUNDATIONS,
WATER TANKS AND RESERVOIRS,
PEN STOCKS, FIREPROOF FLOORS,
. . . WALLS, PARTITIONS, ETC. . .**

Manufactured and Sold by the

EASTERN EXPANDED METAL CO.

602 Paddock Building

BOSTON, MASSACHUSETTS

**THE
HARTFORD PAVING
— *and* —
CONSTRUCTION CO.**

703 Main Street
Hartford, Connecticut

Concrete Arches *and* Foundations

PAVEMENTS

OF ALL KINDS

Artificial Stone Sidewalks

Masonry, Sewers

*Protect the Joints in your
Concrete with the*

HARTFORD WATERPROOF JOINT, patented
and insure good work

Established 1891

350,000 Names and Addresses

Over 1,300 Pages

Issued Annually

Over 15,000 Classifications

THE FIFTEENTH ANNUAL EDITION OF

Hendricks' Commercial Register

OF THE UNITED STATES

For BUYERS and SELLERS

**Devoted to the Architectural, Electrical, Engineering, Iron
and Steel, Mechanical, Railroad and Kindred
industries of the United States**

This Book is the most complete work of its kind ever issued. It includes all Professions and Trades interested directly or indirectly in the Mechanical, Electrical, Architectural, Engineering, Construction, Railroad, Iron, Steel, Machinery, Mill, Mining and kindred trades.

In the lines we cover, every firm appears under its proper classifications, regardless of patronage.

It is invaluable to the Buyer or Seller, the Architect, Engineer, Contractor, Purchasing Agent, Manufacturer, Mine, Millman, Quarryman, Machine Shop, Boiler Shop, Rolling Mill, Foundry, Railroad, Electric Power and Lighting, Plantation, Ship Builder, Lumber Manufacturer or Dealer, Hardware Dealer, Planing Mill, and to every department of Municipal, State and National Government. There is not a Material, Specialty, Apparatus, or any kind of Machinery used in these vast industries under which the name and address of the Manufacturer does not appear properly classified. In fact, the work gives the name and address of the manufacturers of everything made from Iron, Steel, Brass, Bronze, Aluminum, Clay, Stone, Marble, Granite, Slate, Wood, Fibre, Asphalt, Asbestos, etc. In short, it enumerates every Finished Product manufactured from the above-named materials, not omitting the Professions that Specify, the Dealer who handles, the Manufacturers and Contractors who are consumers. This gives you in a nutshell the contents of our Directory. It is bound in cloth, and will be forwarded to any part of the country, expressage prepaid, on receipt of

PRICE, \$7.00

S. E. HENDRICKS COMPANY, Publishers

76 ELM, CORNER FRANKLIN STREET, NEW YORK

Cable Address
HYDOR, N. Y.

Lieber and Western Union Codes Used

Telephone Connection
4980 CORTLANDT

RUDOLPH HERING and GEORGE W. FULLER
Hydraulic Engineers and Sanitary Experts

SPECIALTIES

**WATER SUPPLY
WATER PURIFICATION**

**SEWERAGE
SEWAGE DISPOSAL**

170 BROADWAY

NEW YORK

W. F. KEARNS & CO.

161 Devonshire Street, Boston, Mass.

New England Agents

UNIT CONCRETE STEEL FRAME COMPANY

PHILADELPHIA, PA.

Manufacturers of the Unit System of Re-inforced Concrete

...AND...

THE GENERAL FIREPROOFING COMPANY

YOUNGSTOWN, OHIO

*Manufacturers of Expanded Metal, Metal Lathing, Metal
Furrings, Etc.*

ENGINEERING NEWS

(FOUNDED IN 1874)

The pioneer of American technical journalism and still the
first and final authority of all American Engineers. . . .

Published every Thursday, - \$5.00 a year

Sample copy, with the Engineering News 1906 Buyers'
Guide, containing 1100 names of manufacturers, etc.,
classified under 1287 headings, will be sent for 25 cents
in stamps.

SEND FOR CATALOGUE OF BOOKS

THE ENGINEERING NEWS PUBLISHING CO.

220 BROADWAY, NEW YORK

"GIANT"

THE "OLD RELIABLE"

PORTLAND CEMENT

MANUFACTURED BY

The American Cement Company

Egypt, Pennsylvania

MORE THAN ONE MILLION BARRELS
USED ON THE RAPID TRANSIT SUBWAY

APPROVED AND USED BY PROMINENT ENGINEERS
ARCHITECTS AND CONTRACTORS IN THE MOST IM-
PORTANT WORK FOR THE PAST TWENTY-ONE YEARS

SALES AGENTS

LESLEY & TRINKLE CO.

604-610 Pennsylvania Bldg., Fifteenth and Chestnut Sts., Philadelphia

THE UNITED BUILDING MATERIAL CO.

320 Broadway, New York

101 Milk Street, Boston, Mass.

D. F. KEENAN

Crushed Trap Rock

For MACADAM, BALLAST
CONCRETE DRIVEWAYS
===== ETC. =====

Rough Wall Stone and Bottom Stone Very Cheap

Four Crushers at Work at Quarry Near Newington
800 Tons Daily Capacity

*Stone delivered by Electric Cars along all lines centering at Hartford
or dumped into carts at Bins rear of 173 State Street*

Telephone 1675

OFFICE: ROOM 21, WAVERLY BUILDING

721 Main Street - HARTFORD, CONN.

Represented by DON O'CONNOR

The H. Wales Lines Co.

MERIDEN, CONN.

DISTRIBUTOR OF

**DEXTER
PORTLAND CEMENT**

Ulster County Rosendale Cement

VITRIFIED SALT-GLAZED SEWER PIPE

A full line of all sizes and fittings in stock for prompt delivery

BLUE STONE

PILING

GRANITE

Builders' and Contractors' Material

7 SIZES

to 80 CU. YDS.
PER HOUR

STATIONARY

PORTABLE

HAND POWER

STEAM

GASOLINE

ELECTRICITY



THE CHICAGO IMPROVED CUBE CONCRETE MIXER

THE MIXER OF QUALITY

"IT HAS NO INSIDES"

Any form of inside mechanism in the mixing drum has the function of a separator, which is a term opposed to that of mixing. It is, therefore, obvious that a mixer which depends on any form of separator, such as paddles, scoops, etc., to do the work, cannot be a mixer in the truest sense. *It must be clear that any mixer with inside mechanism has a tendency to produce streaky concrete.* The time being very short in which the actual mixing is done, not a moment should be wasted in any device having a tendency to separate the materials.

It is a well-known fact that mixers having inside blades pocket and separate the material as it enters, and again in turn scoop it up from the bottom, and require constant attention to dislodge the material which is constantly attaching itself to the inside mechanism, not only causing the material to ball, but greatly decreasing the life of the machine, as these accessories, by reason of their resistance, not only wear out rapidly but largely increase the strain on the gears, frame, etc. Our CUBE MIXER, with ordinary use, is guaranteed not to clog.

There is a tendency among all concerns manufacturing mixers to vie with each other in limiting the space of time in which a batch of concrete can be turned out, but without standard of quality by which to compare the products of the various machines the time limit means nothing.

To an unbiased mind it must be evident that the cube principle has an advantage over any other type in the time required for mixing, quality considered.



Send for Catalogue No. 41

Municipal Engineering and Contracting Company

GENERAL OFFICES

607-9-11 Railway Exchange,
Chicago, Ill., U. S. A.



Drawings made with

HIGGINS'

American Drawing Inks—BLACKS AND COLORS

have an excellence peculiarly their own. The best results in Drafting, both mechanical and artistic, can only be attained by using the best Drawing Inks,—

HIGGINS' DRAWING INKS

Send for color card showing actual inks. Bottles prepaid by mail, 35c. each.
At all Dealers, or circulars free from

CHAS. M. HIGGINS & CO., Mfrs., 271 9th St., Brooklyn, N. Y.

The Stoddard-Brown Co.

ENGRAVERS

66 CENTER STREET

NEW HAVEN, CONNECTICUT



LUFKIN

TAPES AND RULES

ARE THE BEST IN THE WORLD.

Made by **THE LUFKIN RULE CO**

NEW YORK
LONDON,

Saginaw, Mich., U. S. A.

SEND FOR CATALOG

FOR SALE EVERYWHERE.

LUDLOW GATE VALVES

ALL SIZES

ALSO

CHECK VALVES

FOOT VALVES

SLUICE GATES

FIRE HYDRANTS

ETC.

BEWARE
OF
IMITATIONS

We also make both electrically and hydraulically operated gate valves and sluice gates. Will cheerfully furnish estimates and designs on application.



ONE OF OUR LARGE ONES

GENUINE

LUDLOW GATE VALVES AND FIRE HYDRANTS

are made only by us and only in Troy, N. Y. They
have the words "LUDLOW, TROY, N. Y." cast on them

NONE GENUINE UNLESS SO MARKED

THE LUDLOW VALVE MFG. CO., TROY, N. Y.

The Lorain Steel Company

Girder Rails

High Tee Rails

...and...

Special Track Work

General Offices

Pennsylvania Building

Philadelphia, Pa.

Also Offices at

New York, N. Y., 74 Broadway
Pittsburg, Pa., Carnegie Building
Atlanta, Ga., Equitable Building
San Francisco, Cal., Union Trust
Building

Chicago, Ill., Monadnock Block
St. Louis, Mo., Chemical Building
Cleveland Ohio, Rockefeller Building
Philadelphia, Pa., Pennsylvania
Building

JOHNSTOWN, PA.

The Celebrated Syracuse Vitrified Paving Brick

MANUFACTURED AT

SYRACUSE, NEW YORK

Eastern References: New Haven, Conn., and Springfield, Mass.

DEPARTMENT OF PUBLIC WORKS

Engineer's Office, Room 17, City Hall

New Haven, Conn., March 1, 1906.

*The New York Brick and Paving Co.,
Syracuse, N. Y.*

Gentlemen: The following streets or portions of streets, in this city, have been paved with "Syracuse" Brick:

In 1892.	York St. (one side), bet. Chapel and Elm Sts.,	633.3 sq. yds.	Sand joints
In 1893.	Ashmun St., bet. Henry and Gregory Sts.,	2,432.1 " "	
In 1894.	Chapel St., at and near State St.,	947.6 " "	
In 1900.	Grand Av., bet. the Mill and Quinnipiac Rivers,	22,697.2 " "	
In 1900.	Commerce St., bet. Cong. Av. and Whiting St.,	2,708.5 " "	Grout joints
In 1901.	Chapel St., bet. York and State Sts.,	13,491.8 " "	
In 1901.	Congress Av., bet. George and Temple Sts.,	4,206.0 " "	
In 1901.	Crown St., bet. State and Temple Sts.,	3,567.8 " "	
In 1901.	Elm St., bet. State and York Sts.,	12,377.2 " "	Grout joints
In 1901.	George St., bet. State and Temple Sts.,	5,661.2 " "	
In 1901.	Temple St., bet. Elm St. and Congress Av.,	7,480.0 " "	
In 1902.	Olive St., bet. State and Water Sts.,	10,341.0 " "	
Total - - - - -		87,546.7 " "	

In 1896-7 about seven miles of "Syracuse" brick gutters for macadam and asphalt pavements were laid. During the year 1902, 545,000 "Syracuse" brick were purchased by the city for repairing pavements not originally laid with "Syracuse" brick. None of the above-named localities has been repaired excepting where the pavement was torn up for a specific purpose. The above total area represents about four miles of streets.

Very truly yours,

HENRY J. KELLOGG,

*Assistant City Engineer,
New Haven, Conn.*



The Sessions Foundry Co.

BRISTOL, CONNECTICUT



Low
Prices

Sewer and Subway Manhole Castings
Sewer Catch Basin Castings, etc.

To
Order

Prompt Shipments

Write us for estimates

Delivery at any point

The Rail Joint Co.

General Offices

29 West Thirty-Fourth St., New York City

Makers of Continuous, Weber and Wolhaupter Rail Joints

Protected by United States Patents

Branch Selling Agencies

APPLY TO ANY OFFICE FOR ILLUSTRATED CATALOGUE

Atlanta, Ga., English American Building
Boston, Mass., India Building
Cincinnati, Ohio, First National Bank
Building
New Orleans, La., Henning Building
Seattle, Wash., Alaska Building
St. Louis, Mo., Commonwealth Trust
Building

Baltimore, Md., Union Trust Building
Chicago, Ill., Monadnock Building
Denver, Colo., Equitable Building
New York, N. Y., 29 West 34th Street
Pittsburg, Pa., Lewis Block
St. Paul, Minn., Pioneer Press Building
Troy, N. Y., Burden Avenue

THE ENGINEERING RECORD

Devotes its pages to articles of special interest to

SUPERINTENDENTS AND MANAGERS OF POWER PLANTS
WATERWORKS ENGINEERS AND SUPERINTENDENTS
CONSTRUCTING AND CONTRACTING ENGINEERS
HEATING AND VENTILATING ENGINEERS
BRIDGE AND STRUCTURAL ENGINEERS
GOVERNMENT AND STATE ENGINEERS
COUNTY ENGINEERS AND SURVEYORS
MILL ARCHITECTS AND ENGINEERS
STEAM AND HYDRAULIC ENGINEERS
RAILWAY AND HIGHWAY ENGINEERS
CITY AND MUNICIPAL ENGINEERS
DRAUGHTSMEN AND ESTIMATORS

Subscription Price - - - - - \$3.00 per year

Sample copy free on request

PUBLICATION OFFICES

114 LIBERTY STREET, NEW YORK

Reinforced Concrete

Bridges

Pneumatic Tubes

Conduits

Paving

Excavating

Russell Contracting Co.

General Contractors

156 Fifth Avenue

New York

SCHERZER ROLLING LIFT BRIDGES

can have an artistic arched form impossible with the swing bridge. They are Modern, Scientific, Economical and Efficient, and are superseding and replacing swing bridges and other old and obsolete types of movable bridges for railroads, electric railways and highways.



Scherzer Rolling Lift Bridge across Newtown Creek, at Vernon Ave., New York City



Scherzer Rolling Lift Bridge across Chicago River, at State St., Chicago

More than seventy swing bridges have already been condemned, removed and replaced by modern Scherzer Rolling Lift Bridges in Greater New York, Chicago, Boston, Cleveland, Buffalo, Saginaw, New Haven, and many other progressive cities at home and abroad.

Highest Award World's Fair, St. Louis, 1904

Write us for Information, Photographs, Sketches and Estimates

THE SCHERZER ROLLING LIFT BRIDGE COMPANY

Main Offices: Monadnock Block, Chicago, U. S. A.

Whitehall Portland Cement

is manufactured in the old Lehigh, Pennsylvania,
District

The Mill is modern and up-to-date in every respect

It is the largest single Portland Cement Mill in the
United States, with a capacity of over 3,000 bbls. per day

Every barrel of Portland Cement produced in this
Mill is sold under the Trademark, "WHITEHALL," and
every barrel that we sell is produced in this one Mill

If Engineers specify any Portland Cements by name,
they should include WHITEHALL, and if their specifica-
tions are based on quality alone, WHITEHALL is always
included

We guarantee WHITEHALL Portland Cement to
meet the requirements of the American Society of Testing
Materials

THE WHITEHALL PORTLAND CEMENT CO.

Principal Sales Office,

1722 Land Title Building, Philadelphia, Pa.

Southern Sales Office

Atlanta, Ga.

New England Sales Office

141 Milk St., Boston, Mass.

Warren Foundry & Machine Co.

ESTABLISHED 1856

Works at Phillipsburg, New Jersey

Sales Office, 170 Broadway, New York

Cast Iron, Water
and Gas

PIPE

From 3 to 48 in.
in diameter

Also all Sizes of Flanged Pipe
and Special Castings

The Edward Balf Company

26 STATE STREET, HARTFORD, CONN.

GENERAL TRUCKMEN
AND CONTRACTORS

MOSLER SAFES DELIVERED

BUILDING STONE

CRUSHED STONE

SAND

GRADING

EXCAVATING



E. G. SOLTMA'N
125 E. 42d St., New York, N. Y.
Next to Grand Central Station

Continuous Prints made from
PROFILES
drawn on transparent Profile or
Cross Section Tracing Paper

PRICES for Large Prints up to 4 1/2 x 12 feet

BLACK	Prints on Paper, per sq. ft.,	3c
"	" " Cloth, " " "	5c
BLUE	" " Paper, " " "	2c

DRAWING MATERIALS

BLUE PRINT PAPER

SEND FOR PRICE LIST

MENTION THIS PUBLICATION

LEVELS AND TRANSITS

Engineers'
Supplies



Surveyors'
Outfits

WRITE FOR
CATALOGUE O

SLIDE RULES
5-8-10-15-20" in length

KOLESCH & CO. 138 FULTON ST., NEW YORK

Connecticut Trap-Rock Quarries

INCORPORATED

CRUSHED TRAP-ROCK
FOR BALLAST, MACADAM, CON-
CRETE, WALKS, DRIVES, ETC.

OFFICE

101 MEADOW STREET, NEW HAVEN, CONNECTICUT

Shipments by rail to all points reached by The N. Y., N. H. & H. R. R. Co.

Daily Capacity of Crushers, 4,000 Tons

THE SMITH MIXER

1600 NOW IN USE

Mixes Rapidly

Mixes Thoroughly

Mixes Cheaply

Mixes Constantly



Saves Time

Saves Labor

Saves Cement

Saves Repairs

Contractors' Supply & Equipment Company

Old Colony Building, Chicago

170 Broadway, New York



C. L. BERGER & SONS

SUCCESSORS TO BUFF & BERGER

37 William Street

BOSTON, MASS.

SPECIALTIES

Surveying Instruments of Precision

ALL KINDS

ALL SIZES

Catalog on Application

H. STEVENS'S SONS CO.

MANUFACTURERS OF

Sewer and Railroad Culvert Pipe

FIRE BRICK, PREPARED CLAY, RIDGE TILE
FIRE PROOFING, UNDERGROUND CONDUITS, ETC.

MACON, GEORGIA

Keuffel & Esser Company

127 Fulton Street, New York

Branches : Chicago, St. Louis, San Francisco



Drawing Materials Surveying Instruments Measuring Tapes

We are the largest manufacturers of *Levels, Transits, Sextants, Compasses, Hand Levels, etc.* Our instruments are of most approved and advanced construction, and have many (patented) improvements.

All requisites for field and mine engineering.

All requisites for the Drafting room. Paragon, Key Brand and other Drawing Instruments.

Blue Print, Brown Print, Black Print Papers and Printing Apparatus, also for printing by Electric Light.

K & E Patent Adjustable Engine
Divided *Slide Rules*, 5, 8, 10, 16, 20 inch.



K & E Measuring Tapes

We manufacture Steel, Metallic, Linen, Cotton Tapes, Pocket Tapes, Band Chains, Flat Wire Tapes, Etc. *Most accurate. Largest assortment. The best.*

ALL GOODS WARRANTED.

Complete Catalog, 1906 (550 pages) on request.

*Highest } Grand Prize St. Louis, 1904.
Awards } Gold Medal, Portland, 1905.*

THE WATSON & JACKSON Corp.

HARTFORD, CONN.

Distributors of
Standard Brands of

Portland and Rosendale Cements

Granite
Curbing
Crosswalks
and
Belgian Blocks



Blue Stone
Flagging
Granolithic
Walks
and Driveways

We make a Specialty of

GRANITE BOUNDARY STONES

Having furnished over 500 to the
City of Hartford in the last two years

Westinghouse

Traction Brake Co.

Straight, Automatic
and
Combined Air Brakes
For Electric Railway Service

Motor-Driven Air Compressors

Storage Air Brake Systems

Westinghouse Traction Brake Company

General Offices, Pittsburg, Pa.

Boston, 638 Exchange Building, 53 State St.

Buffalo, 774 Ellicott Square Building

Chicago, 1545 Railway Exchange Building.

Cincinnati, 1111 Traction Building.

Cleveland, 1007 New England Building.

Columbus, 1132 Columbus Savings & Trust Building.

Denver, 604 Majestic Building.

Los Angeles, Cal., 527 South Main St.

Mexico City, Mexico, 4½ Calle de San Diego.

New York, 2014 Trinity Building, 111 Broadway.

Richmond, 804 American National Bank Building.

St. Louis, 1932 North Broadway.

St. Paul, 634 Endicott Building.

Oakland, California, 1601 12th Street.

For Canada: Canadian Westinghouse Co., Limited, Hamilton, Ontario.

Apparatus Manufactured by The Westinghouse Air Brake Co.

Westinghouse Generators and Motors



Standard the World Over

For information address

Westinghouse Electric & Mfg. Company

Sales Offices in All Large Cities

Pittsburg, Pa.

For Canada: Canadian Westinghouse Co., Limited, Hamilton, Ontario

FRANK OBERKIRCH, *President*

LOUIS STREUBER, *Vice President* GEORGE C. SIMONS, *Sec'y and Treas.*

D. B. ANDERSON *Gen'l Manager*



St. Marys Sewer Pipe Co.

Sewer Pipe, Flue Linings

and all other clay products

St. Marys, Pa.

Long Distance Telephone



WM. BANFIELD, Pres.

A. C. HOUSTON, Vice-Pres.

F. W. OWESNEY, Sec'y-Treas.

THE

East Ohio Sewer Pipe Co.

IRONDALE, OHIO

MAKERS OF

VITRIFIED PIPE

Sewer Pipe

Culvert Pipe

Chimney Pipe

Flue Linings

Wall Coping

Fire Brick

GEORGE CURTIS, Eastern Sales Manager

First National Bank Building

NEW HAVEN, CONN.

THE WARNER-MILLER CO.

NEW HAVEN, CONNECTICUT

WHOLESALE

EXPANDED METAL

FOR REINFORCING CONCRETE FLOORING, ETC.

SEWER PIPE



BLUESTONE

EXPANDED STEEL LATH

PAVING BRICK

**PROMPT DELIVERIES MADE FROM STOCK AT
NEW HAVEN**

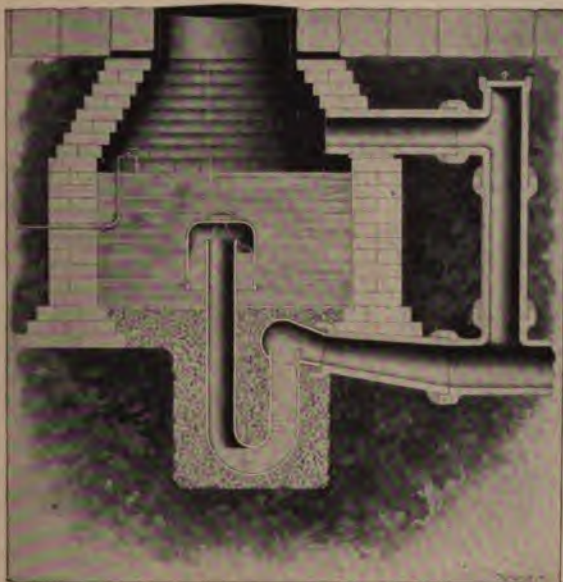
PACIFIC FLUSH TANK COMPANY

84 LA SALLE STREET, CHICAGO, ILL.

Manufacturers of the

Miller Automatic Siphon

FOR INTERMITTENT FLUSH TANKS



Used for Flushing Street Sewers

No Moving Parts No Joints No Little Traps

*Received the Highest Award in its Class at the World's Columbian Exposition
for Simplicity of Construction, Effectiveness and Reliability*

NEW HAVEN, CONN., March 1st, 1906.
The sewage filtration plant for Springside Home, New Haven, is equipped with an eight-inch special Miller Siphon, and has worked satisfactorily since put into operation, September 23d, 1899.

(Signed) H. J. KELLOGG, C. E.

Each Siphon Guaranteed Absolutely

Send for Illustrated Catalogue

THE
Tuttle, Morehouse & Taylor
Company

PRINTERS and BOOKBINDERS

123 Temple Street, corner of Crown
New Haven, Conn.

Facilities and Qualities the best

STATIONERY DEPARTMENT

183 Crown Street

Full Line of Stationery. Engraving and Steel Die Work

C. W. Blakeslee

D. A. Blakeslee

D. W. Blakeslee

Clarence Blakeslee

C. W. BLAKESLEE & SONS

58 Waverly Street, New Haven, Conn.

General Contractors

*Experts in Street Paving and
Macadam Road Making*

Steam and Electric Railroads, Dams, Sewers
and Heavy Masonry Built

Building Stone, Crushed Stone and Belgian Blocks Furnished

THE PERFECT ROADWAY

Adopted by 110 Cities in U. S. and Canada

THE BITULITHIC PAVEMENT

Its Phenomenal Record Tells Its Own Story

SEE HOW IT GROWS

	Sq. Yds.
1901.....	16,400
1902.....	440,831
1903.....	915,630
1904.....	940,239
1905.....	1,091,825
1906 (to June 1).....	1,573,734

ITS SUPERIOR QUALITIES

1. Non-Slipperiness
2. Durability
3. Light Traction
4. Practically Noiseless
5. Absolutely Waterproof
6. Easily Cleaned
7. Sanitary

Let us tell you what the greatest experts say of
BITULITHIC. Write

WARREN BROTHERS COMPANY

BOSTON, - MASS.

Registered Trade Marks

"Bitulithic" "Puritan" "Bituminous Macadam" "Bitrock"

ESTABLISHED 1845

INCORPORATED 1900

W. & L. E. GURLEY

TROY, NEW YORK

LARGEST MANUFACTURERS IN AMERICA OF

Civil Engineers' and Surveyors' Transits

TRANSITS, PLANE-TABLES, CURRENT-METERS, ETC.



Y-LEVELS, COMPASSES, LEVELING-RODS, CHAINS, ETC.

Dealers in Steel and Metallic Tape Lines, Barometers, Anemometers,
Drawing Instruments, Paper, Vellum, Colors and Brushes, Pro-
tractors, Scales and Rules, T-Squares, Triangles, Curves,
Pocket-Compasses, Magnifiers, Telescopes and Field-Glasses
PRICE LIST, ILLUSTRATED, MAILED ON APPLICATION

2 plans
1 chart.
C.S.T.

D. E. BRADLEY
President

GEORGE H. SAGE
Vice President

SEYMOUR N. ROBINSON
Treasurer

Berlin Construction Company

STEEL BUILDINGS, BRIDGES
AND STRUCTURAL WORK



STEEL-CONCRETE CONSTRUCTION A SPECIALTY

OFFICE AND WORKS: BERLIN, CONN.

220 Broadway
NEW YORK

131 State Street
BOSTON, MASS.

22 Clinton Street
NEWARK, N. J.

P 18 1999

CONNECTICUT SOCIETY
OF
CIVIL ENGINEERS



1907

VIA

Genuine Rosendale Cement



Used in the construction of nearly all the
Yale Buildings, New Haven, Conn.

Over one hundred miles of sewers in New Haven
were built with Rosendale

ONE PROMINENT ARCHITECT WRITES

"I have uniformly specified and insisted on your Cement, sometimes when others would have been easier to get, and have found it superior for floor work to Portland."

CONSOLIDATED ROSENDALE CEMENT CO.

F. N. STRANAHAN, Sales Agent

26 Cortlandt Street

New York City

23

✓
Connecticut
Society of Civil Engineers



Papers and Transactions for 1906

AND

Proceedings

OF THE

Twenty-Third Annual Meeting

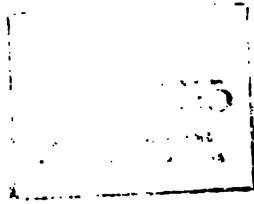
AT

HARTFORD, FEBRUARY 12 and 13, 1907



New Haven
THE TUTTLE, MOREHOUSE & TAYLOR COMPANY
1907

EH



Connecticut Society of Civil Engineers

ORGANIZED AT BRIDGEPORT, JANUARY 15, 1884



Officers for 1907

D. S. BRINSMADE, DERBY, ... *President*
EDWARD W. BUSH, HARTFORD, ... *First Vice President*
FREDERICK J. EASTERBROOK, NEW HAVEN, *Second Vice President*
J. FREDERICK JACKSON, NEW HAVEN, ... *Secretary and Treasurer*

Directors

GEORGE K. CRANDALL, NEW LONDON.
JOHN K. PUNDERFORD, NEW HAVEN.
CHARLES F. CHASE, NEW BRITAIN.
HENRY J. KELLOGG, NEW HAVEN.

CONTENTS.

The Charter Oak Sewer System Method of Assessment (Alger- non B. Alderson)	1
Discussion	131
Description of Concrete Curb on Park Terrace, Hartford, Conn. (Herbert G. Clark)	7
Discussion	139
Some Engineering Features of the Norwich Hospital for the Insane (C. E. Chandler)	10
Discussion	151
Transverse Contours for Roadway Pavements (H. H. Gladding)	26
Completion and Operation of the New Haven Water Company's Filter Plant (Chas. A. Ferry)	29
Discussion	143
Some Tests in Sighting at Leveling Rods and Stadia Rods (John C. Tracy)	38
Discussion	145
The Highway Bridges of the New Haven Improvements (C. L. Slocum)	46
Discussion	146
The New Haven Cut (John F. Trumbull)	62
Discussion	128
Laying of Submerged Pipes (Frederick S. Wardwell)	79
Discussion	152
The New Connecticut River Bridge (N. Y., N. H. & H. R. R.), Lyme, Conn. (J. H. Soehrens)	87
Discussion	149
Telephone Subway Construction (Edward H. Everit)	96
Discussion	152
Epochs of Transportation (Lewis M. Haupt, C.E., Sc.D.)	111
Discussion	127
In Memoriam—John W. Bacon, William B. Cochrane, Arthur P. Law, Benjamin F. Hathaway	156-64
PROCEEDINGS	
Report Board Direction	165
" Secretary	167
" Treasurer	168
Address of President	170
Legislative Matters	176
Election of Officers	191
Summer Meeting	202
Constitution and By-Laws	204
List of Members	212

LIST OF EX-PRESIDENTS

WITH DATES OF SERVICE

B. HULL	1884, 1885
CHARLES M. JARVIS	1886
CHARLES E. CHANDLER	1887
CHARLES H. BUNCE	1888, 1889
F. FLOYD WELD	1890
E. P. AUGUR	1891, 1892, 1893, 1894
WM. G. SMITH	1895, 1896
ROBERT A. CAIRNS	1897, 1898
EDWIN D. GRAVES	1899, 1900
HENRY J. KELLOGG	1901
CLARENCE B. VORCE	1902
FREDERICK L. FORD	1903
JOHN K. PUNDERFORD	1904
ALBERT B. HILL	1905
CHARLES F. CHASE	1906

THE CHARTER OAK SEWER SYSTEM METHOD OF ASSESSMENT.

By Algernon B. Alderson.

The purpose of this paper is to show how the assessment was computed in accordance with the law under which the Board of Sewer Commissioners of the town of West Hartford were empowered to act, and further with due regard to the limitations of area as defined by an agreement made between our commissioners and the officials of the city of Hartford.

Vol. XI, Special Laws of Connecticut, page 138, section 3, says: "Said commission is authorized to apportion and assess the expense of laying out, constructing, altering, and repairing such sewers, and of procuring rights of way, outlets, and privileges therefor, upon the lands and buildings in said town which shall, in their judgment, be specially benefited thereby, whether they abut on the sewers or not, and upon the owners of such land, subject to the right of appeal as hereinafter provided; and the commission shall give notice of the assessment so made, by publication thereof in two daily newspapers published in Hartford, within one month after the assessment is made. .

Sec. 4. Wherever such commission shall lay out or cause to be laid out any public sewer in said town, in whole or in part, through or across land of individuals or corporations, not used as a highway, and cannot agree with the owners of the land or persons having an interest therein, as to the damage to be paid for such land or interest, they shall by themselves, or by a committee of indifferent persons by them appointed, appraise the damage to such land caused by taking the right of way for such sewer, and shall notify the owners of the land or persons interested therein of such layout, and of the damages allowed them therefor respectively. If the owners of such land or persons so interested shall be dissatisfied with the appraisal so made, they may, within ten days after such notice is given,

apply to one of the judges of the Superior Court for the appointment of a committee to reappraise such damages; first giving three days' notice in writing to said commission of the time and place of making such application; and said judge shall appoint three judicious and indifferent freeholders, residents of Hartford County outside of the limits of said town, who shall be sworn to faithfully discharge the duties of their appointment, and who shall give notice in writing of the time when they will view the premises and reassess such damages, to the owners of the land or persons interested therein, three days before the time when they will view the premises and reassess such damages to said parties; and at the time named, after having heard the parties interested, they shall reappraise and reassess the damages, and report the same to the Town Clerk of said Town in writing, and said reappraisement shall be final and conclusive between all the parties interested."

For the benefit of those who would acquaint themselves more fully, I again refer them to Vol. XI, as I have quoted only that portion of the law which relates more particularly to the adjustment of assessments.

Let it be clearly understood that the town treasury of West Hartford does not pay any portion of the expense incurred in promoting sewerage. There are at present no less than five separate sewer districts, each of which must bear its own cost of development.

An agreement was signed by officials of the City of Hartford, and the Town of West Hartford, May 12, 1902, for an outlet for sewerage only from Charter Oak district; see Vol. 17, p. 141, Town Records.

\$10,000 was paid the City of Hartford as follows:

For connection with and use of Prospect Avenue sewer	\$6,000.00
For use and maintenance of Intercepting sewer.....	4,000.00

The plan of assessment comprises four items as follows:

Item (1) \$8,440.08, being amount after deduction is made for share in construction cost of Prospect Avenue sewer; this amount has been levied on the total assessable area in the district and is distributed equally among all property holders according to their precise area. The total assessable area in

the district is 87 214/1000 acres. Assessment per acre, 96 7744/10,000 dollars.

Item (2) \$6486.55 represents cost of trunk sewers, engineering, legal expenses and interest on notes. Trunk sewers are all sewers over and above eight inches in diameter, excepting Prospect Avenue sewer (built by the City of Hartford), which minimum for local consideration is ten inches in diameter. The above amount (\$6486.55) has been levied on the total area in the district in the same manner as Item (1).

Item (3) \$6644.00 for "local sewers" consists of the cost of an eight-inch pipe and appurtenances equal in length to the total length of the system built by the town, plus the cost of a ten-inch pipe and appurtenances equal in length to the Prospect Avenue sewer, this being the cost of a sewer in front of each individual property were a larger size not required on account of the accumulation of sewage from other properties. This item is applied directly to each property in proportion to its front footage, if a sewer has been actually constructed. Charge per front foot for local sewers, Item (3), .54833 cents.

Item (4) House connections, consists of the cost of six-inch house connection pipe laid to curb line at 50 cents per foot and is charged directly to the property to be served.

Item (1) outlet and (2) trunk rights have been assessed on the respective property owners in proportion to the area of their holdings. It would be more logical in a sanitary or house drainage system such as this, to assess at a given rate per house lot, but the undeveloped condition of a large portion of the district (which should nevertheless pay its share of the items chargeable to the system as a whole) precluded the possibility of such form of assessment.

It may appear to some that items one and two are excessive when applied to area irrespective of its location, but upon examination of the map it will be noted that all property is closely related to rapid transit, and may be developed for building purposes within a reasonably short time.

It would be imposing on your good nature to relate all the circumstances which led to the necessity of acquiring an outlet for this district. It is sufficient, however, for me to assure you that the location would not in any sense permit of the introduc-

tion of a plant for the treatment and disposal of sewage, and therefore made it imperative for the Sewer Commissioners to secure an outlet from the city.

An appeal was taken from the assessment items one and two, and the testimony of the plaintiff brought out many interesting claims especially considering the location and elevation of his property. We all know how the property owner feels when the subject of taxes is broached, no matter in what form, and invariably he deplores the position in which he is placed, until some of us who are not lordly land owners offer to exchange places with him, in order that we may enjoy the privilege of paying taxes. It is then that he realizes more fully his obligation.

In the appeal above referred to, the plaintiff claimed inability to sewer a certain portion of land that was depressed, losing sight of the fact that in developing any property a somewhat uniform grade must be adopted; likewise he claimed exemption for probable street area, established street areas having been deducted in arriving at sum of Item (1). My argument was to the effect that it was an injustice to levy a higher unit upon the other owners, when there was no definite means of determining location and size of plaintiff's streets. Another claim made was that on account of his entering the interceptor or trunk near its outlet, he ought to have a reduction on Item (2), trunk rights, being unable to comprehend the factors that contribute to the design and capacity of sewer systems.

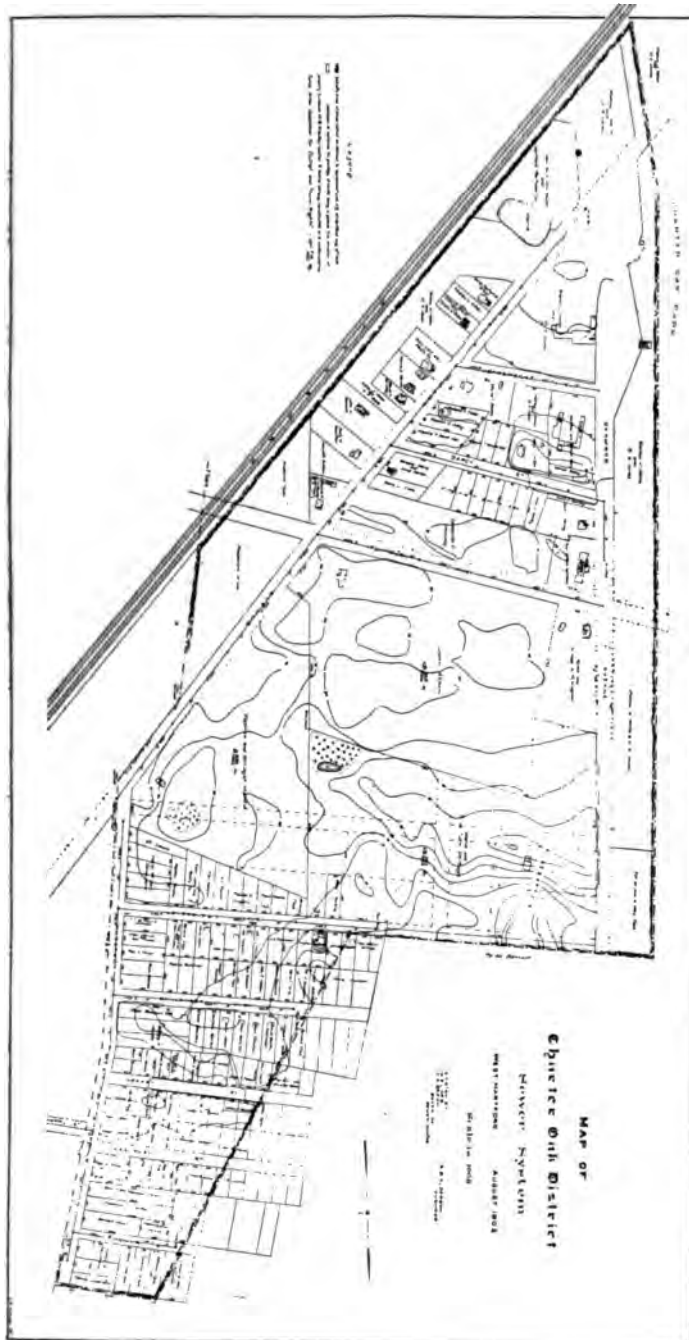
You will be interested to note a comparison of the assessment as levied by the Town when compared with the City's. Take for instance, a building lot on the west side of Prospect Avenue 50 x 150: the several items were as follows:

Outlet	\$16.64
Trunk Rights	12.79
8" Local Sewer	27.42
H. C. 6" pipe	7.00
	\$63.85 or

\$1.277 per front foot.

The City of Hartford assessed on the east side of Prospect Avenue \$1.3073 per front foot.

Again allow me to state that in my opinion too much importance cannot be attached to the privilege, or rather the right, I



might say, which the property owners acquire to sewer their property at any time. While it is true that an assessment cannot be distributed without apparently imposing a hardship on some, the benefit is nevertheless enjoyed by the majority.

Considering the Town of West Hartford topographically, and its important relation to the City of Hartford as a most desirable residential suburb, it is extremely difficult to consider at all the installation of sewage purification plants within its borders. It is fair to assume that its territory is tributary to Hartford's sewer system, and one cannot help but feel that a misfortune happened when the main elevation of Hartford's system was determined, at least in so far as West Hartford is concerned, for to connect the center district (the outlet for which has been secured) long minimum grades will have to be maintained.

In conclusion, I may state that in distributing the assessment for privilege of outlet in the Park Street sewer district, West Hartford, I used the same method, i. e., assessed according to area no matter where located always provided that it was tributary on the basis of reasonable grades. No appeal was made from this statement.

I hope our members may feel inclined to express their opinion on the plan herein described, as I feel that perhaps where a district is very large in its proportions, the determination of various zones differing in value from the standpoint of future development, may justly necessitate the application of a varying unit of assessment, for both privilege of outlet and trunk rights.

It is true that in laying before you the particulars of the method employed, I may invite criticism. This, if merited, I accept with composure, believing that engineers rarely are all of one opinion.

DESCRIPTION OF CONCRETE CURB ON PARK TERRACE, HARTFORD, CONN.

By Herbert G. Clark.

During the summer of 1906 the Hartford Paving and Construction Company constructed about 5000 ft. of concrete curb on Park Terrace for the city of Hartford.

Park Terrace was laid out as a boundary road around Pope Park in a series of curves of various radii from 100 to 1500 ft. in length, the profile being made up of straight grades connected by vertical parabolic curves.

On this account, the laying out of the curb required five or six times as much engineering work as would have been necessary on the straight lines and grades of the ordinary street.

The curb was built in alternate ten-foot lengths, the intermediate spaces being filled in after the removal of the forms from the completed sections.

In order to place the forms in correct alignment and grade, stakes were set at 10-foot intervals opposite the ends of each section on a radial offset of 2.5 ft. back from the curb-line, the tops of the stakes being driven to the required grade.

The curves were first run out in chords of about 40 ft., and the intermediate 10-foot stations were located by measuring the required offsets from these chords, thus diminishing the irregularities in alignment due to the transit angles and to "the man behind the gun."

The forms were made of $1\frac{3}{4}$ " plank for curves of over 300 ft. radius, boards from $\frac{1}{2}$ " to $\frac{3}{4}$ " in thickness being used on curves of from 10 to 100 ft. radius. After the ends of the forms were securely braced at the correct line and grade, and the Wainwright rail was clamped in position, the forms were sprung to the required curvature as determined by the middle ordinate of a 10-foot chord of the given radius.

On all curves of less than 100 feet radius, the rail must be

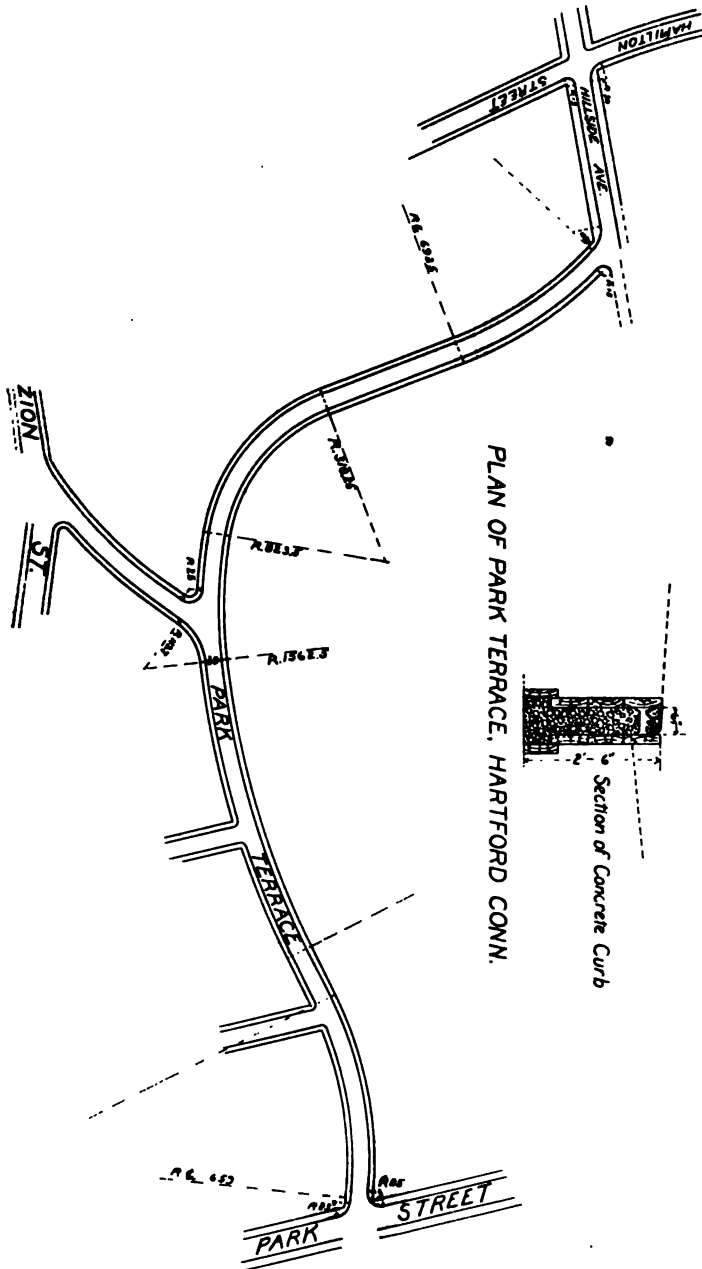
bent at the rolling-mill; on longer radii, the rail can be sprung to the required curvature.

The concrete consisted of a 1—1½ and 3 mixture of Portland cement, sand and crushed trap rock, the latter being one inch or less in size.

The upper three or four inches of the curb was made of 1—1½ Portland cement mortar, with lampblack added to give a uniform flagstone color.

The top of the curb was finished by troweling, and, after removing the forms, the back and front of the curb were given a wash of cement grout, thoroughly brushed in and rubbed in with pieces of burlap sacking, no plastering being necessary to give a smooth surface.

The finished work presents a very regular and uniform appearance, and we hope it will hold its position much more permanently than the ordinary 20-inch granite curbing generally used.



SOME ENGINEERING FEATURES OF THE NORWICH HOSPITAL FOR THE INSANE.

By C. E. Chandler.

The site of the hospital is a sandy plateau on the Thames River $2\frac{1}{2}$ miles from the city of Norwich. The State owns several hundred acres of land varying in elevation from tide water to about 200 feet above. Through this land runs a brook with a drainage area of about one square mile. A rectangle enclosing present and proposed buildings contains about 20 acres and is from 70 to 80 feet above tide water. The area of roofs will probably be about $2\frac{1}{2}$ acres and the two hollow squares to be enclosed by the buildings have an area of about 14 acres.

The drainage area of the Thames River at the site is about 1500 square miles. The Worcester and New London branch of the N. Y., N. H. & H. R. R. and the Norwich and Westerly trolley pass through the land of the State on either side of the buildings.

SEWERS.

The main sewer discharges directly into the Thames River, with its invert at one foot above mean tide, enabling the sewer to be carried to the face of a wharf when built.

The sewers beginning at the outlet consist of 24-inch cast iron pipe on a one per cent. grade, 12-inch cast iron pipe on a 47 per cent. grade up the bluff, 24-inch Akron pipe on a one per cent. grade, followed by smaller sizes down to ten-inch taking surface water, six-inch taking soil pipes or two roof water pipes and five-inch for one roof water pipe. All soil pipes are heavy cast iron, protected by traps and fresh air inlets. The 24-inch pipe on a one per cent. grade gives capacity for about $3\frac{1}{2}$ inches of run-off per hour from the roofs, which are slate and rather steep, and about one inch per hour from enclosed spaces, where subsoil is loose sand.

As the sewer system is designed and built in accordance with ordinary practice, perhaps the only points of interest are the method of disposal and the size of the main sewer.

As there is no probability of there being any buildings near the outlet except the power station, and the drainage area of the stream is so large, no nuisance or harm is anticipated from the discharge of the crude sewage directly into the stream.

As to the sizes, the writer believes that the large area of roofs and enclosed spaces, taken in connection with the possi-



GENERAL VIEW OF HOSPITAL SITE.

bility that the institution will eventually become much larger than is now anticipated, fully justifies the sizes adopted.

When the length of main sewer is short and a liberal estimate does not call for a diameter of more than 24 inches, the saving by reducing sizes does not justify the risk.

WATER SUPPLY.

The first appropriation for hospital buildings was so small that a temporary water supply had to be provided for the first patients, their attendants and the large amount of construction work going on. Water in the only well on the plateau stood

about 70 feet below the general level of the ground, and it could supply but a trifling amount of water.

The brook heretofore mentioned was in a ravine about 40 feet deep that separated the plateau from the high rocky land beyond. Two shallow experimental wells were dug and stoned near the brook and a small dam across the brook made by the contractors enlarged.

These supplied water from the opening of the hospital in October, 1904, to December 6, 1905. During this period the number of patients increased to 129 with 33 employees. The amount of water used was a little less than 100 gallons daily per patient. Partly as an experiment and partly to provide water in the driest of the season of 1905, in case the shallow wells and brook should prove insufficient, a six-inch well was drilled 140 feet deep, mostly in ledge.

The amount of water obtainable with surface pump was only about five gallons per minute and a deep well pump was installed with which about 25 gallons per minute could be obtained. This was used for a short time by building contractors.

For these temporary supplies no elevated storage was provided except two 500-gallon tanks in the attics of the first wards. These tanks hold about 400 gallons each between high and low water. In order to have some fire service, several four-inch stand pipes were placed in the wards and a 150-gallon electric pump was located near the shallow wells and brook. The pump was controlled by a starter in the temporary power house.

A low alarm signal notified the engineer in the power house that tanks located about 350 feet to the west were nearly empty, upon which he would start the electric pump situated 500 feet to the east, and when the tanks were nearly full, about five minutes later, the high alarm bell would ring and the engineer would shut off the current. This plan worked perfectly for 14 months without an interruption until a permanent supply was obtained.

For a permanent supply two reservoirs were planned, one on the brook heretofore referred to and one on the high ground. It was first intended to locate the brook reservoir at a point outside the land owned by the State, at a point from which the

water could flow to the new power station by gravity and from which it should be raised by a steam pump.

The large prices asked for land and rights caused a change in plans, and a reservoir on the brook containing five and one half million gallons was built on land owned by the State. All the trees, roots and soil were removed from the reservoir except a small amount at the extreme upper end. An earthen dam with a concrete core wall and rollway was built. There was no suitable gravel available, but plenty of sand, and stones four



LOWER RESERVOIR.

inches to sixteen inches in length. The concrete was made by filling tight forms with thin one to three mortar into which the above stones were thrown. The result was a very tight concrete with a smooth surface. For more detailed description of this kind of concrete see annual report of the Connecticut Society of Civil Engineers, 1904. For the gate chamber the same concrete was used with smaller stones.

The core wall extends down to hardpan or clay, but the southerly end went horizontally well into clean sharp sand, which sand probably extends through the plateau for several

thousand feet. The gate chamber rests on hardpan. It has two openings controlled by ordinary double faced gates about five feet and ten feet below full pond.

A possible innovation was the substitution of grooves in the concrete in place of iron guides for the screens. These cost nothing to speak of, as they were formed by nailing beveled strips to the forms and putting in a reinforcement of some metal from a scrap heap.



ROLLWAY LOWER RESERVOIR.

The concrete rollway is left one foot down with grooves for flashboards to satisfy the common desire to put on flashboards no matter how high the dam.

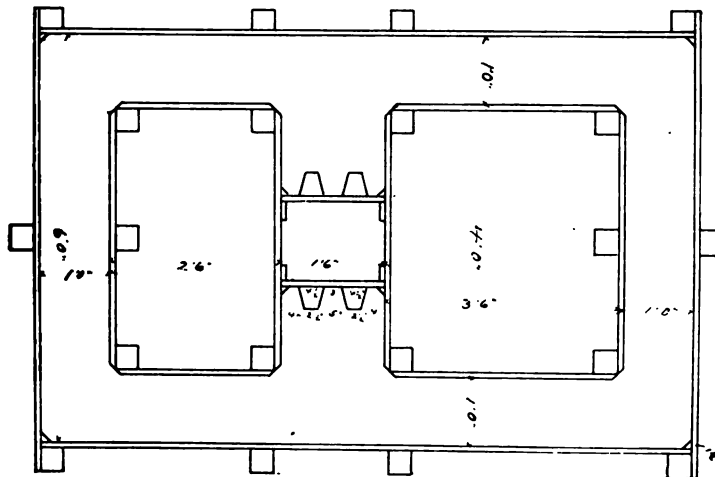
A roadway nearly the whole length of the reservoir built at trifling expense served three purposes: a road to haul and distribute pipe on; an approach to the dam, and a channel diverting from the reservoir the watershed of the main road and trolley.

A narrow side hill road on a grade contour enabled the pipe to be distributed. The material excavated for the trench widened the road. The filling of the trench from material excavated from the bank widened the road still more.

The other reservoir holds about 700,000 gallons and the overflow is at elevation 184, or more than 100 feet above the hos-

pital grounds. It was made by removing all the soil, mud and vegetable matter from a natural depression having the hardest kind of a clay hardpan bottom and building a small earthen dam with concrete core at the natural outlet. Into this reservoir were led several small springs by loose drain tile and the reservoir had a drainage area of about 18 acres. These springs and slight watershed supplied the hospital, with 132 patients and 34 employees, from December 6, 1905, to May 21, 1906, including water used by builders. During the summer it supplied a portion of the water used.

Whenever this upper reservoir becomes less than two-thirds full, the previously mentioned 150-gallon pump raises water



PLAN OF GATE HOUSE.

from the lower to fill the upper reservoir; thus the latter acts both as distributing reservoir and as a source of supply.

Except a few days after emptying and refilling pipes or reservoir, the water has had none of the tastes or odors common to that from new reservoirs, and it has proved especially good for boilers.

On a part of the upper reservoir site about two feet of mud overlaid clay hardpan. Around the edges was thin ordinary soil, then yellow loam and then hardpan. Nearly half the area was literally paved with boulders of all sizes. We expected to remove the loose boulders and vegetable matter, supposing that

the fast boulders were imbedded in hardpan. Unfortunately, the black soil and muck filled with roots extended entirely underneath great numbers of boulders of a half a yard or more capacity, requiring their removal with a derrick. How the black soil got under the boulders the writer does not know.

The 10-inch pipe, which is both inlet and outlet of the reservoir, has an ordinary cast iron strainer and is located horizontally in a small basin in the bottom of the reservoir. The sides of the small basin were paved with stone and its bottom covered with clean fine gravel to prevent the stirring up of the clay by the incoming water. The strainer was flanged and connected with the bell of the regular pipe by a short piece of cast iron pipe with a flange at one end and spigot at the other.

The first day's pumping made the water about three feet deep over the strainer and connecting special, and the first night about two inches of nice black transparent ice formed. The next morning a perfect picture of the strainer and special appeared in white on the black ice over them. The effect was very striking, positively uncanny. The picture included every paving stone as well as the strainer and pipe. The curvature shading, and the outlines of the flanges and mouldings on the bell were perfect. A clue to the cause is furnished by the fact that the pump had lost its priming and pumped air for some time. That this air should rise to the ice and eventually turn it white is plain enough to every boy who has slid or skated on ice, but why did the air attack the ice in such a way as to portray every feature of the pipe and strainer?

The upper reservoir is connected with the lower reservoir and the hospital buildings by a ten-inch cast iron pipe. This extends to the new power house, where a fire pump is to be installed. Leading back from the power house is an eight-inch pipe, with which all fire hydrants and stand pipes are connected. A cross-over with checkvalve connects the ten-inch and eight-inch pipes. All water for other than fire purposes comes from the ten-inch pipe.

With this arrangement the 700,000 gallon reservoir with a 100-foot head stands all the while on both the fire pipes and the other pipes.

When the fire pump is started it will draw from the ten-inch and force into the eight-inch, thus increasing the fire pressure

and slightly decreasing the pressure on the ordinary fixtures. It can be arranged to pump river water into the fire pipes without danger to the water used for domestic purposes.

POWER, HEAT AND LIGHT.

A temporary power station with one 150 h. p. boiler, one 75 h. p. engine and one 50 kw. generator was first installed. These single units with the one motor and one pump never failed in



POWER STATION, BRIDGE AND CHIMNEY DURING ERECTION.

their duty of heating, lighting and supplying the hospital with water.

The permanent power station is located near the river and steam railroad, and consists of steel columns and beams, with floors and stairs of concrete, and walls of wire lathing plastered

outside and in, the combined thickness being about two inches put on in five coats.

The foundations are of concrete piers and concrete girders. There are no foundation walls. The steel columns are inclosed by a plastering of concrete on wire lath but are not imbedded in concrete.

The smoke stack is circular, six feet in diameter in the clear, and 150 feet high. It is composed of two walls, six and eight



COMPLETED STATION BRIDGE AND CHIMNEY.

inches thick respectively, for about 90 feet in height, and one wall six inches thick for the balance of the height.

The material is concrete reinforced with steel rods that extend into a concrete foundation 10 feet deep and 18 feet square, in which are imbedded a network of steel rails. The outer wall was built first in forms and the inner wall was built later of hollow concrete blocks. Reinforcing rods were put in the hollow spaces in the blocks and grouted in.

The stability of the chimney is not dependent on its weight, but on the tensile strength of the rods. A retaining wall supports a bank ten feet high, on which is laid the spur track

over which coal and other supplies come in. It is of reinforced concrete one foot thick and 10 feet above finished grade and $3\frac{1}{2}$ feet below finished grade. It has a footing extending horizontally under the bank on which the track rests five feet. Triangular buttresses, ten feet apart on centers, reinforced by large rods, connect the footing and vertical wall, thus making



SUBWAY IN PROCESS OF ERECTION.

the bank hold down the footing, that holds up the wall, which holds up the bank in turn.

The boiler room contains three 150 h.p. boilers with room for five others. The pump room will contain a fire pump, two boiler feed pumps and receivers, and cold storage machinery.

The engine room contains a 50 kw. electrical unit and a hundred kw. electrical unit with room for another.

Electricity is furnished for lighting the buildings and grounds, pumping water and running laundry machinery. Steam is furnished for heating and drying.

Hot water is furnished for use throughout all the buildings.

SUBWAYS AND CORRIDORS.

The power house is connected with all the buildings by a subway eight feet square so that supplies of all kinds can be



SUBWAY SHOWING PIPES, IN CULVERTS.

taken from the cars on the spur track, lifted by the elevator and run in small cars to the basement of any building. The subway is built of reinforced concrete with a six-inch bottom, eight inch walls and five to six-inch roof. Under the subways are pipe culverts $3\frac{1}{2}$ feet wide and twenty inches deep covered with reinforced concrete slabs $2\frac{1}{2}$ inches thick and 22 inches wide. The absolute necessity of using the best of material and labor

in such slabs and putting the reinforcement in the right place will be promptly discovered by any one who makes such slabs in any other way.

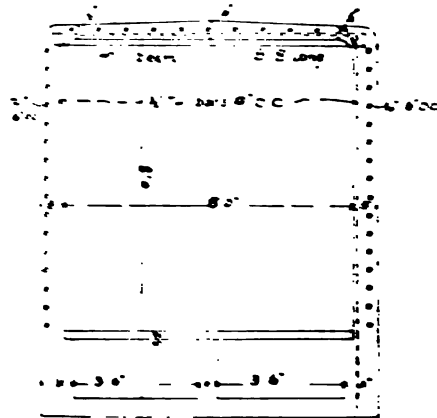
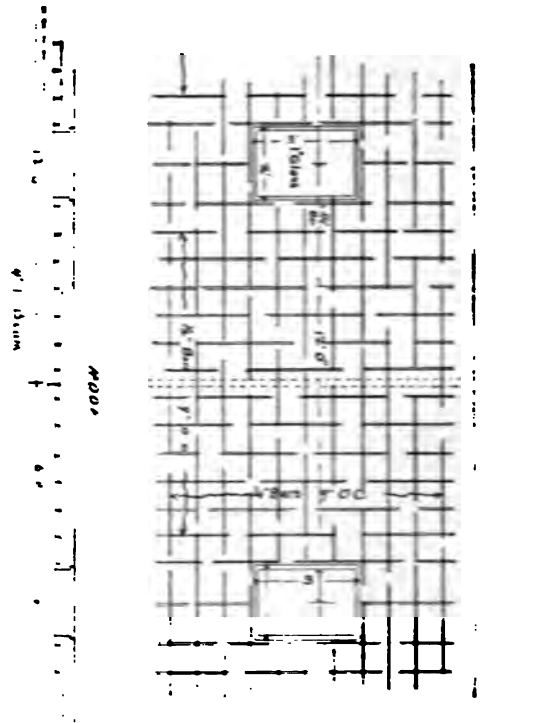
The main subway has in one pipe culvert the ten-inch and eight-inch cast iron pipes heretofore mentioned and in the other culvert are the return steam pipes, the hot water supply and return pipes. Overhead are the 12-inch low pressure steam



CORRIDOR WITH SLABS IN PLACE.

pipe, a four-inch high pressure steam pipe and cables carrying electricity for light and power. The subway is well lighted by heavy glass plate in the roof.

Some trouble was experienced in leaks around the glass plates, and it was obviated by removing the iron frames and imbedding the plates in mimwax. Mimwax was also used when other leaks existed.



SECTION OF SUBWAY

PLAN OF SUBWAY.

The subway proper begins at the top of the bluff about 100 feet from the power house and about 50 feet above the power house floor. The subway and power house are connected by a reinforced concrete bridge with same interior dimensions as the subway supported on pairs of concrete piers.



FORMS FOR RETAINING WALL.

BUILDINGS.

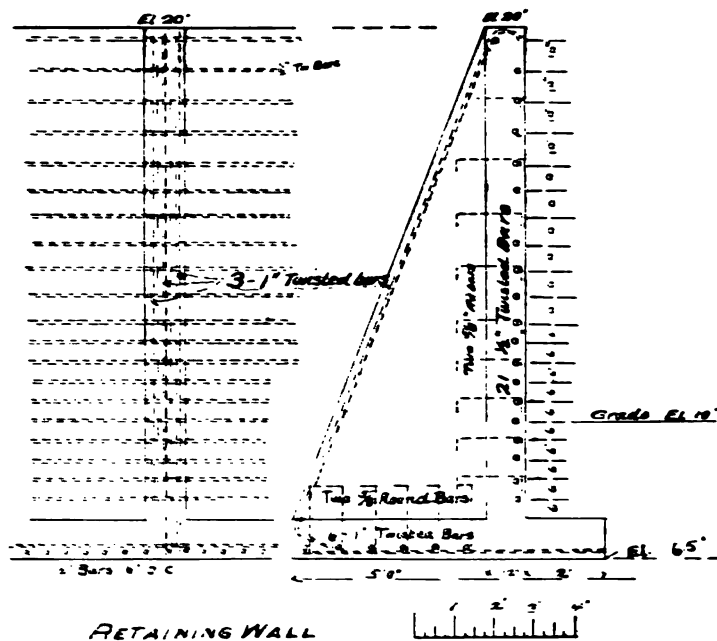
The buildings all have brick walls and fireproof concrete floors and partition walls and either slate or concrete stairs.

There is nothing to burn in walls, floors and partitions except doors, window sashes, door and window frames and in rooms occupied by patients a wooden floor consisting of $\frac{7}{8}$ -inch hemlock and $\frac{7}{8}$ -inch maple nailed to screeds imbedded in concrete.

The laundry roof is of concrete while other roofs are of wood and slate. The oven weighs about 120 tons and is supported on concrete columns and girders.

No concrete-blocks were used on any of the work herein described except on the inner chimney wall.

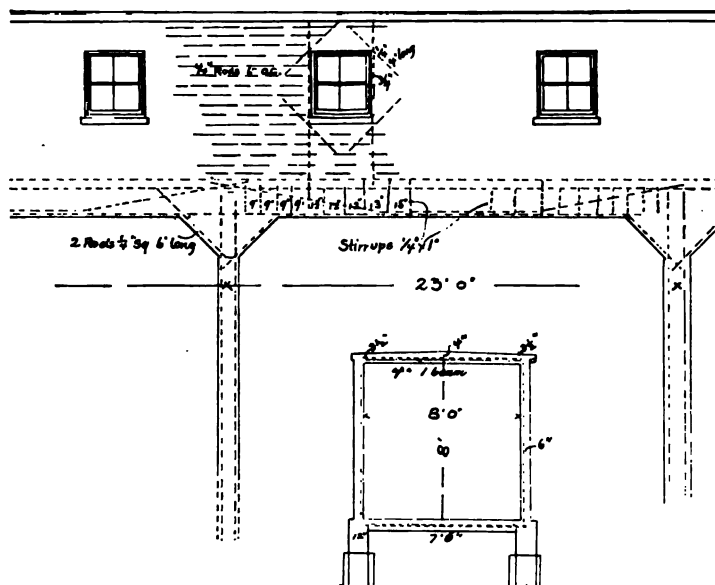
The architects are Cudworth & Woodworth of Norwich, Conn., assisted by Mr. R. D. Kimball of Boston, Mass., on the power, lighting and heating. C. E. Chandler and S. B. Palmer of Norwich, Conn., are the civil engineers and surveyors.



PLAN OF RETAINING WALL.

The sewers first contracted for were built by Peck McWilliams Company of Norwich. The water works and later sewers were built by Archibald Torrance of Norwich on a percentage basis.

The concrete power station smoke stack, bridge and a part of the subway was built by Simpson Bros. Corporation of Boston, the laundry and kitchen and a part of the subway by the Torrington Building Company of Torrington, Conn., and the four wards and a part of the subway by A. N. Carpenter of Norwich, Conn.



SECTION OF BRIDGE.

TRANSVERSE CONTOURS FOR ROADWAY PAVEMENTS.

By H. H. Gladding.

Let l represent the horizontal distance from the vertex to the lower end of the curve.

Let d represent the total difference in elevation between the ends of the desired curve.

Let nd be any assumed portion of d .

Let $(1-n)d$ be the remaining portion of d .

Let x and y be the coordinates of any point on the curve, the origin being at the vertex.

The broken line in the sketch is a preliminary curve tangent to the horizontal at the vertex, and with its lower end at a distance nd below said horizontal line: its ordinates will be found by the usual parabolic formula, $y = \frac{x^2}{l^2} nd$.

Suppose this curve to be rotated about the vertex until its lower end has moved downward through the remaining portion of d , viz., $(1-n)d$: the additional ordinates caused by this rotation will be in direct proportion to their horizontal distances from the vertex, and will be expressed by $\frac{x}{l} (1-n)d$.

The sum of these two partial ordinates will, of course, give the ordinates of the curve in its final position: so that we have for the general equation, $y = \frac{x^2}{l^2} nd + \frac{x}{l} (1-n)d$, from which equation the tables were computed.

The advantages of this tipped down curve are an increase of initial pitch at the vertex, and a lessening of the slope at the steepest part of the curve.

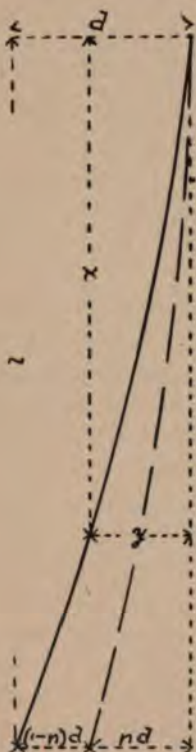
The amount of the total ordinate d of the curve is a matter for the judgment of the engineer in charge. $d = .04l$ will probably

TRANSVERSE CONTOURS FOR ROADWAY PAVEMENTS
GENERAL EQUATION, $y = \frac{x^2}{l^2}nd + \frac{x}{l}(1-n)d$
TABLES SHOWING VALUES OF y IN TERMS OF d FOR DIFFERENT VALUES OF n

$x = \frac{1}{4}l$	$\frac{1}{4}l$	$\frac{1}{2}l$	$\frac{3}{4}l$	l
$n = \frac{1}{4}$	.132	.278	.438	.611
$\frac{1}{2}$	.120	.259	.417	.593
$\frac{3}{4}$	.097	.222	.375	.555
1	.074	.185	.333	.518
$\frac{3}{4}$	.062	.167	.313	.500

$x = \frac{1}{2}l$	$\frac{1}{2}l$	$\frac{3}{4}l$	l	$\frac{5}{4}l$	$\frac{3}{2}l$	$\frac{7}{4}l$
$n = \frac{1}{4}$	.098	.203	.316	.438	.566	.703
$\frac{1}{2}$	.089	.188	.297	.417	.547	.687
$\frac{3}{4}$	.070	.156	.258	.375	.508	.656
1	.052	.125	.219	.333	.468	.625
$\frac{3}{4}$	.043	.109	.199	.312	.449	.609

$x = \frac{3}{4}l$	$\frac{3}{4}l$	l	$\frac{5}{4}l$	$\frac{3}{2}l$	$\frac{7}{4}l$	$2l$
$n = \frac{1}{4}$	.078	.160	.248	.340	.438	.540
$\frac{1}{2}$	.070	.147	.230	.320	.417	.520
$\frac{3}{4}$	.055	.120	.195	.280	.375	.480
1	.040	.093	.160	.240	.333	.440
$\frac{3}{4}$	.033	.080	.143	.220	.313	.420



$x = \frac{1}{2}l$	$\frac{1}{2}l$	$\frac{3}{4}l$	l	$\frac{5}{4}l$	$\frac{3}{2}l$	$\frac{7}{4}l$	$2l$
$n = 1$	.091	.184	.279	.376	.475	.576	.679
$\frac{1}{2}$	.082	.168	.258	.352	.450	.552	.658
$\frac{3}{4}$	.073	.152	.237	.328	.425	.528	.637
1	.064	.136	.216	.304	.400	.504	.616
$\frac{1}{2}$	.056	.120	.195	.280	.375	.480	.595
$\frac{3}{4}$	.046	.104	.174	.256	.350	.456	.574
1	.037	.088	.153	.232	.325	.435	.553
$\frac{1}{2}$	.028	.072	.132	.208	.300	.408	.532
$\frac{3}{4}$	.019	.056	.111	.184	.275	.384	.511

be sufficient for roads carefully shaped by a road roller. For very smooth, hand-laid pavements, $d = .03l$ would seem ample.

EXAMPLE:— $l = 15'$, $d = .04l = 0.6'$; take $n = \frac{3}{4}$. From the table, the ordinates at $\frac{1}{4}$, $\frac{1}{2}$ and $\frac{3}{4}$ of the distance from the vertex to the gutter will be $.11d$, $.31d$ and $.61d$; or in feet, $.066'$, $.186'$, $.366'$.

The initial pitch at the vertex is the amount of the tip down, $(1-n)d$, divided by l , and in the above example amounts to $.01$, a one per cent. grade.

The middle ordinate between the curve and its subtending chord is equal to $\frac{1}{2}d$ minus the middle ordinate to the curve from the horizontal line through the vertex as taken from the table in terms of d ; and in the example used is $.5d - .31d = .19 \times .6' = .114'$.

COMPLETION AND OPERATION OF THE NEW HAVEN WATER COMPANY'S FILTER PLANT

By Chas. A. Ferry.

Two years ago I presented a paper to this Society describing the new filtration plant of the New Haven Water Company at Whitneyville, at that time under construction. Since that time the works have been completed, and for the past ten months have been supplying an average of about eight and one half million gallons per day of filtered water to the city of New Haven.

Upon the completion of the structure preparations were made for securing the sand and gravel for the filtering material. The Water Company owned extensive beds of sand and gravel about a mile and a half from the plant, which a mechanical analysis showed to be suitable for the purpose.

Plans were made, and the necessary machinery secured for washing and separating the materials into the various sizes required.

We soon found, however, that theory and practice are widely at variance where sand screening and washing are concerned, and we were obliged to do considerable experimenting before our apparatus could be made to work to our satisfaction.

As finally constructed, our plant consisted of a hopper into which the material was dumped as it was carted from the bank. From this it was elevated about 15 feet by a chain and bucket elevator and dumped into the screens. These consisted of three hexagonal screens arranged concentrically on a shaft, varying in length from 7 feet for the outer to 13 ft. 10 in. in length for the inner screen. These screens were held in position, 4 inches apart, by means of four spiders fastened to the shaft and carrying, by means of lock nuts on the arms of the spiders, $2\frac{1}{2}$ " x $1\frac{1}{4}$ " strips of wood, to which the wire netting was fastened. The outer, or sand screen, was of $\frac{1}{10}$ -inch; the second of $\frac{1}{4}$ -

inch, and the third $\frac{1}{2}$ -inch mesh. Crushed trap rock was used for the two coarser layers of stone.

The screens were set on a slope of one in eight. The mixed material was dumped at the upper end and, as the screens revolved, the material gradually worked its way to the lower end, except the sand which passed through its screen, where it was delivered into chutes which conveyed it to separate storage bins.

Over the top of the screens was placed a 3-inch water pipe perforated with $\frac{1}{8}$ -inch holes every $\frac{1}{2}$ inch, which delivered a shower of water onto the screens and converted the sand into a semi-fluid condition and prevented the screens from clogging. To successfully screen sand by machinery, it must be thoroughly dry, or else mixed with a sufficient amount of water to make it run freely; in any intermediate condition the screens will choke up and no sand will pass through. This is a trick which we learned only after considerable experimenting.

After passing through the screen the sand was received into a box, where it received its first washing. It was expected that one washing would be sufficient to remove all of the finer material, but we found that it was practically impossible to remove all of the particles below the $\frac{1}{100}$ -inch limit.

The sand, instead of being single crystals, was largely composed of conglomerates, exceedingly fine particles cemented together with oxide of iron. These rough particles retained the silt, which no amount of washing would entirely remove. It is probable, however, that the sand as delivered to the beds is actually better than the mechanical analysis would show, as a certain amount of fine material is produced by the attrition of the sand grains against one another and against the wires in passing through the sieves. It was found that by passing the sand twice through the sieves the amount of material passing the finest sieve was about doubled.

From the receiving box the sand was carried by a $1\frac{1}{2}$ -inch pipe into the washing machine, which consisted of a box 12 feet long, 32 inches wide and 26 inches deep at the inlet, and 32 inches deep at the outlet end. On the bottom of the box was laid, its entire length, three lines of 4-inch pipe connected by a 5-inch main to the water tank located on top of the sand storage bins. These pipes were perforated every $2\frac{1}{2}$ inches, on the

under side, with $\frac{3}{8}$ -inch holes for the first half of the pipe and $\frac{1}{2}$ -inch holes for the remainder. The sand was admitted at the shallow end of the box and moved gradually to the deeper end, where it was discharged from the hopper; in the mean time being separated from the finer particles, which were carried by the current of water to the surface, where it overflowed into a drain which carried it away.

From the hopper the sand was raised by an elevator to the storage bin. This was 12 feet long, 8 feet wide and held about 25 cubic yards. It was raised a sufficient height above the ground to permit of the sand being delivered by chutes into the carts. The bottom of the bin was made water tight, on a slant of one in six. On the bottom was nailed $\frac{1}{2}$ -inch square battens on which were tacked a layer of $\frac{1}{4}$ -inch wire netting and on this another course of $\frac{1}{8}$ -inch mesh. This provided free drainage for the sand pile and quickly removed all water not held by capillary attraction. Along the lower edge of the bin was suspended a trough which conducted the water to the drain.

A direct acting pump with 5-inch suction and 4-inch discharge supplied the 750-gallon tank, located on the top of the bins, with water; and a 15 h. p. engine furnished power for running the screens and elevators.

Three men were required to run the plant. About 75 cubic yards of material could be screened and washed per day, and the total cost of putting the prepared sand and gravel into the bins, not including the cost of the plant, was about thirty-seven cents per cubic yard.

The sand did not furnish a sufficient amount of the finest grade of gravel, or grits, for our requirements and an effort was made to supply the deficiency from Long Island, but the dealers there would not furnish us with the grits unless we purchased sand also, and as the Water Company were very anxious to get the filters into working order as soon as possible, a contract was made with the captain of a steam barge to furnish us with such amount of sand and gravel as we might need.

This sand was brought from the White Star Sand Co. of Northport, L. I., and was of much better quality than that obtained from our local beds. It consisted entirely of crystals, was very uniform in size, was remarkably free from particles finer than $\frac{1}{100}$ -inch; some samples having none whatever and

scarcely any having more than .2 per cent., while samples of the local sand which tested as low as .5 per cent. were rare, although, as previously stated, a considerable portion of this was probably caused by the breaking up of some of the conglomerates in passing through the sieves. Our specifications for sand were: Material which will pass a screen with one tenth of an inch mesh and will not contain more than one half of one per cent. of material which will pass a screen with one one-hundredth of an inch mesh. It shall have an effective size of not less than twenty-five one-hundredths of a millimeter nor more than thirty-five one-hundredths of a millimeter; and shall have a coefficient of uniformity of not more than two and one half.

The first sand which we got out, and the first shipments from Long Island, were nearly alike as to size and uniformity, and it was put together indiscriminately in the beds, but, subsequently, the local sand ran finer while the white sand ran coarser, and it was then placed in separate beds. The local sand varied from about 0.24 to 0.27 millimeters for effective size while the Long Island sand ran from about 0.34 to 0.36 mm. Both sands appear to give about the same result as regards the quality of the effluent; but the fine sand beds will not run quite so long without cleaning as those filled with the coarser material.

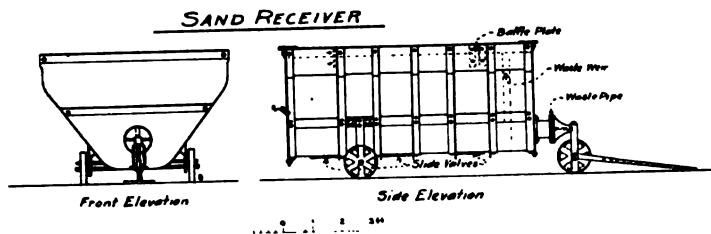
The depth of the sand in the different beds varies from 2 ft. to 3 ft. 8 in. in order to secure regular rotation of the beds; the bed with the least depth being left idle as a receptacle for washed sand from the other beds.

The water is maintained at a constant depth on the beds by means of a balanced float valve placed on the 12-inch inlet pipe.

Two or three engineers who had had experience with valves of this type gave us the cheering assurance that this portion of our apparatus would give us more trouble than all of the remainder put together, and, when we made our first test their doleful prophecy seemed destined to be fulfilled, for, when the water rose to within about two inches of the established level, the valve began to pound at the rate of a blow every two or three seconds with a force which threatened to break every joint in the pipe line.

These valves were cone-shaped, and the back of one valve presenting a larger surface to the current of water than the

The sand is shoveled into small piles with a broad, flat, iron shovel and is then wheeled in barrows to the ejector, which is stationed near the center of the bed. It is then shoveled into the ejector and from thence is carried by the stream of water to the first hopper of the washing machine; from here it is carried, in the same manner, to the second hopper and from thence, in the same way, to the sand receiver; the dirty water overflowing the top of the hoppers into the collecting troughs and from thence passing to the sewer.



The sand settles to the bottom of the receiver and the water overflows the partition and discharges into the sewer through the spiral riveted pipe before mentioned. The sand receiver is suspended from the roof of the filter, the roof being strengthened and provided with eye bolts at three places in each bed for that purpose.

The entire work of moving the sand from the time it is shoveled into the ejector in one bed until it is taken from the receiver in another bed is done by water, no manual labor being required except that one man is employed in keeping the side collecting troughs of the washing machine free from sand, a small amount of which is carried over by the water.

Ten men are usually employed in cleaning. The setting up and taking down of the apparatus, the cleaning of the bed and resurfacing of the sand, occupies about one day for each bed.

The water pressure, at present, is only forty pounds. This is only about one half the pressure used in other filter plants, and is too low for the rapid handling of the sand. A new pump has been purchased but not yet installed, which will increase the pressure to one hundred pounds.

Daily bacteriological tests are made of the water; samples being taken of the applied water, of the effluent from each bed, from the main leading to the clear water well and from the main leading from the pump to the reservoir.

The accompanying table shows the average weekly results of the daily tests since the first of last May. No *B. coli* have ever been found in any of the samples of the filtered water although they are frequently found in the applied water.

The platinum chloride test is used in determining the color. The average turbidity varies from 0 to 10 parts per million; practically all of this is removed.

A curious phenomenon has been observed in connection with the loss of head of the water in passing through the sand, which has puzzled us, and which no theory yet advanced has explained to our satisfaction. When the beds are clean, the loss of head is only about 0.2 ft. and little change is noted for two or three weeks; then it increases at a gradually accelerated rate until the loss is about $5\frac{1}{2}$ ft., when the filter stops passing water and the bed has to be cleaned.

On two occasions, when the loss of head had reached about $2\frac{1}{2}$ ft. the loss of head has suddenly dropped back to 0.2 ft. and has then steadily risen to the $5\frac{1}{2}$ ft. limit.

I wish here to acknowledge my indebtedness to Mr. Walter J. Connor, bacteriologist at the filter, for the assistance he has rendered in the preparation of this paper.

				Bacteria per Cubic Centimeter			Color.		
				Applied Water.	Filtered Water.	Percentage of Bacteria Removed.	Applied Water.	Filtered Water.	Percentage Removed.
Week ending	May	5, 1906	.....	131	18	86			
"	"	" 12, "	.....	191	17	91			
"	"	" 19, "	.....	108	14	90			
"	"	" 26, "	.....	70	8	90			
"	"	June 2, "	.....	658	20	97			
"	"	" 9, "	.....	252	30	90			
"	"	" 16, "	.....	175	32	81			
"	"	" 23, "	.....	240	30	90	17	8	53
"	"	" 30, "	.....	112	13	80	15	8	46
"	"	July 7, "	.....	154	27	82	12	7	42
"	"	" 14, "	.....	142	13	91	10	6	40
"	"	" 21, "	.....	132	12	91	8	5	37
"	"	" 28, "	.....	175	11	94	6	4	33
"	"	Aug. 4, "	.....	183	16	91	5	3	40
"	"	" 11, "	.....	175	15	91	8	4	50
"	"	" 18, "	.....	133	27	80	7	3	57
"	"	" 25, "	.....	117	12	90	8	5	38
"	"	Sept. 1, "	.....	221	15	93	7	5	30
"	"	" 8, "	.....	156	15	90	8	5	37
"	"	" 15, "	.....	195	11	95	7	4	43
"	"	" 22, "	.....	160	16	91	7	4	43
"	"	" 29, "	.....	201	15	93	7	3	55
"	"	Oct. 6, "	.....	113	9	92	7	4	43
"	"	" 13, "	.....	117	13	90	8	5	37
"	"	" 20, "	.....	160	12	93	9	4	55
"	"	" 27, "	.....	2140	15	99	12	7	42
"	"	Nov. 3, "	.....	394	15	97	20	16	20
"	"	" 10, "	.....	170	16	94	25	20	20
"	"	" 17, "	.....	216	8	96	18	12	33
"	"	" 24, "	.....	633	9	98	12	10	20
"	"	Dec. 1, "	.....	366	8	98	12	8	33
"	"	" 8, "	.....	295	5	98	12	8	33
"	"	" 15, "	.....	303	8	97	12	9	25
"	"	" 22, "	.....	443	6	99	10	8	20
"	"	" 29, "	.....	480	5	99	9	7	22

SOME TESTS IN SIGHTING AT LEVELING RODS AND STADIA RODS*

By John C. Tracy.

This paper gives the results of four sets of tests made to determine the probable errors in the following operations:

- (1) Setting a target on a leveling rod.
- (2) Reading a rod directly without using a target.
- (3) Measuring horizontal distances with the stadia.
- (4) Measuring differences in elevation by the stadia and vertical-angle method.

The object in each case was to determine the *maximum* error likely to occur in ordinary practice, rather than to ascertain the highest degree of precision which might be attained in special cases. For this reason conditions for the tests were chosen which were more unfavorable than those that prevail in ordinary practice. Not only were many of the instruments and rods in poor condition, but the work was assigned to students just beginning the subject of surveying, and who were, therefore, much less skilful than the average surveyor.

With more than one hundred and twenty-five students in the field at one time, an excellent opportunity was afforded to obtain a large number of observations from which to calculate the probable errors by the theory of least squares. Some of the results given are based upon as many as 1200 independent measurements. The probable error of a *single* observation determined from a large number of observations, indicates the precision which may be expected in *any* single observation made under the same conditions.

* In a book on surveying to be published during the present year by John Wiley & Sons, there are several chapters dealing with the errors which occur in the use of different surveying instruments. In the preparation of these chapters it was necessary to make a number of tests, among which were those described in this paper.

PROBABLE ERROR OF SETTING A LEVEL TARGET.

Conditions. Three levels were used. Levels No. 1 and No. 2 were 18" wye-levels, $1\frac{3}{8}$ " objective, and magnifying power of about 35 diameters. Level No. 3 was a 15" wye-level, $1\frac{1}{8}$ " object glass, and magnifying power of about 30 diameters. Each of the three level rods had a vernier scale on the target. The sun was shining and the air was "boiling" slightly.

Method of Procedure. At each level was a party of eighteen students, each of whom had used the level just long enough to become accustomed to sighting. The rod rested on a solid support 100 ft. from the level, care being taken to hold it plumb while each student in turn set the target. In order that there should be as little disturbance of the level as possible it was set up with two leveling-screws in the line of sight, an umbrella was held over the instrument, and an instructor kept the bubble in the center of its tube. In this way the discrepancies between the target settings by different students were due almost wholly to errors in sighting. To eliminate as far as possible errors in reading, an instructor read the rod for all settings. The tests were repeated with the rod at 200 ft. and 300 ft. from the level. Each of the quantities in the following table is the probable error of a *single* observation calculated from eighteen observations.

TABLE I

Instrument.		Length of Sights.		
		100	200	300
Level No.	1.....	0.00196	0.00196	0.00370
"	" 2.....	0.00147	0.00229	0.00327
"	" 3.....	0.00130	0.00157	0.00213

Conclusions. The results, as obtained from 54 observations at each distance, indicate that for beginners, at least, the chances are even that the error of sighting and of setting the target will not exceed, say 0.002 ft. for a 100-ft. sight, 0.0023 ft. for a 200-ft. sight and 0.0037 for a 300-ft. sight. With better instruments and more experienced observers very likely the errors would be less, but probably the results are not far from those obtained in ordinary practice. Incidentally, the effect of the sun shining on the instrument was made very apparent by taking readings after the umbrella had been removed.

PROBABLE ERRORS OF READINGS MADE WITHOUT A TARGET.

Conditions. Readings were taken by more than one hundred students working in pairs, but, unfortunately, no precautions were taken to protect the instruments. A larger number of levels were used, some of which were decidedly inferior to those described above; and the "speaking" rods were of various styles, with graduations more or less dim from constant wear. Each quantity in the table is the probable error of a single observation as computed from more than 100 observations at each distance.

TABLE II.

Length of Sight.....	50	100	150	200	250	300
Probable error	0.0024	0.0035	0.0038	0.0048	0.0062	0.0065

Conclusions. In the preceding test the discrepancies in setting the target were due almost wholly to errors in sighting, but in this test, since no precautions were taken to shade the level or to keep the bubble in the center, the errors were due in part to changes in the instruments. Hence the target readings and the direct readings cannot be compared, except that it is evident that the target readings are but slightly more accurate than direct readings, even though taken under much more favorable conditions. The speed gained in the use of a self-reading rod is obvious, and these results confirm the belief that the target is an encumbrance, rather than a help, in a large part of ordinary leveling. As a matter of fact, a self-reading rod is generally used in precise leveling, where a result reduced from the readings obtained from three horizontal cross-hairs is probably more accurate than a single observation upon an ordinary target.

In ordinary leveling the errors made in estimating fractional parts when a self-reading rod is used are compensating, so that in running a line of levels the results would be even more accurate than the table would indicate.

PROBABLE ERRORS OF HORIZONTAL MEASUREMENTS MADE WITH THE STADIA.

Conditions. Five transits were used of several different makes; magnifying power of telescopes from 20 to 24 diam-

eters; adjustable stadia wires; constant correction about 1.1 ft. Stadia rods K and E No. 6284.

Method of Procedure. Five stakes for each transit were driven, approximately in line, on level ground and at distances of about 100 ft. apart. These distances were not measured with a tape until after all the stadia readings had been taken. Each transit was set up over the first stake in its row and approximately 50 students read the stadia distance from each transit to each of the four stakes in the corresponding row. The distances to the first stakes varied from 90 to 125 ft.; to the second stakes from 185 to 210 ft., and so on up to a little more than 400 ft. for the last stake in each row. With ordinary instruments the accuracy of the stadia reading decreases rapidly for distances greater than 400 ft., and hence tests were not carried beyond that point. None of the students who took the readings had had experience in the use of the stadia, in fact most of them had never sighted at a stadia rod until a few minutes before the tests were begun. The results indicated that in a number of cases the student forgot to add the constant correction of one foot, but such results were allowed to stand and only an occasional blunder of an even 10 ft. was thrown out. Each of the quantities in the following table is a probable error of a single observation as found by least squares from approximately forty to fifty readings by different students. Thus the table represents about 1000 different readings.

TABLE III.
PROBABLE ERRORS OF A SINGLE OBSERVATION.

Distances		90-125	185-210	285-300	415-435
Transit No. 1.....		0.28	0.46	0.94	1.07
" " 1.....		0.51	0.74	0.77	0.96
" " 2.....		0.55	1.19	0.95	0.83
" " 2.....		0.76	0.87	0.90	1.22
" " 3.....		0.40	0.63	0.71	0.79
" " 3.....		0.25	0.46	0.55	0.78
" " 4.....		0.39	0.90	0.64	0.96
" " 4.....		0.92	0.32	1.18	0.62
" " 5.....		0.69	0.58	0.82	0.97
" " 5.....		0.51	1.07	0.84	1.08
Mean		0.51	0.72	0.83	0.93
Minimum		0.25	0.32	0.55	0.62
Maximum		0.92	1.19	1.18	1.22

Conclusions. The results show that, so far as sighting is concerned, the chances are even that the maximum error which will occur in reading distances by the stadia method will not greatly exceed one foot up to distances of 400 ft. The mean of the probable errors 0.5, 0.7, 0.8 and 0.9 ft. for 100, 200, 300 and 400 ft., respectively, represent more nearly what may be expected in practice. These results do not indicate, however, the discrepancies to be expected between tape measurements and stadia measurements, since such discrepancies will involve constant errors, which are not involved in the mere act of reading the rod, such, for example, as errors in the wire interval and errors in rod graduations. In order, therefore, to determine what the discrepancies really were, each of the distances was measured with a tape. Each quantity in the following table is the mean of approximately 50 discrepancies, i. e., the readings of approximately 50 students at each transit and for each distance were compared with the tape measurement for that distance and the mean of the 50 discrepancies entered in the table.

TABLE IV.
MEAN DISCREPANCIES BETWEEN STADIA AND TAPE MEASUREMENTS.

Distance	90-125	185-210	285-300	415-435
Transit No. 1.....	0.58	0.66	1.37	1.77
" " 2.....	0.65	1.30	1.09	1.30
" " 3.....	0.57	0.65	0.73	1.87
" " 4.....	0.44	0.63	0.93	0.99
" " 5.....	0.70	1.50	1.60	2.40
Mean	0.59	0.95	1.14	1.66
Minimum	0.44	0.63	0.73	0.99
Maximum	0.70	1.50	1.60	2.40

It is evident from the table that transit No. 5 gave much poorer results than the other transits. This inferiority is not so evident in Table III and is therefore probably due in large measure to poor adjustment of the stadia wires. Allowing the results to stand as they are, it would appear that the average discrepancy between horizontal measurements as found with the stadia and with the tape are about 0.6, 0.9, 1.1 and 1.7 ft. for 100, 200, 300 and 400 ft., respectively. Of the five transits No. 5 was by far the poorest. It had been in use more than

twenty years, and though the stadia wires were adjusted before the tests were made, it is probable that the wire interval was incorrectly taken. The maximum discrepancies as indicated in the lower row are, therefore, larger than those which would occur in ordinary practice. It should be kept in mind also that all the quantities in the table represent results obtained under most unfavorable conditions.

PROBABLE ERRORS OF VERTICAL MEASUREMENTS MADE WITH
THE STADIA.

From Table III 0.5, 0.7, 0.8 and 0.9 are the mean of the probable errors in sighting at distances of 100, 200, 300 and 400 ft., respectively. Taking these quantities as a basis and assuming that the error in the vertical angle will not exceed a minute, the error in differences of elevation may be computed from the usual stadia reduction formula. In the same way, taking the maximum values from Table III as 0.9, 1.2, 1.2 and 1.2, respectively, the maximum probable errors may be computed in the same way. These values are given in Table V for angles of 3°, 5°, 10°, 15° and 25°, the latter angle being as large as is likely to occur in practice.

TABLE V.
ERRORS IN ELEVATION FOR AN ERROR OF ONE MINUTE, BASED ON THE
PROBABLE ERRORS IN TABLE III.

Vert. Angle. Distances.	3°		5°		10°		15°		25°	
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
100.....	0.07	0.05	0.11	0.07	0.18	0.12	0.25	0.15	0.36	0.21
200.....	0.11	0.09	0.16	0.12	0.27	0.18	0.35	0.23	0.50	0.31
300.....	0.14	0.12	0.19	0.16	0.30	0.23	0.38	0.28	0.52	0.37
400.....	0.16	0.15	0.22	0.20	0.33	0.27	0.40	0.33	0.54	0.42

The above table is based on the error of sighting only. The mean values in Table IV, however, are less than the maximum values in Table III, except for 400 ft., so that the results in Table V indicate approximately what may be expected in ordinary practice, provided the error in the vertical angle does not exceed one minute. Thus for example, the error in elevation should ordinarily not exceed 0.4 ft. for angles up to 15° and sights up to 400 ft. If, however, the transit is as unreliable as No. 5, which gave an error of 2.4 ft. in a horizontal distance

of 400 ft. (see Table IV), the resulting error for one minute error in a 15° vertical angle would be about 0.7 ft. for a 400-ft. sight. The error in the vertical angle is affected not only by the reading of the vertical arc, but also by the adjustments of the level tube and the sensitiveness of the bubble. Hence, it may easily exceed one minute. If, however, it is as large as 5 minutes, the error in elevation as obtained by Transit No. 5 would not exceed 1.1 ft. in a 400-ft. sight.

As a test of the actual discrepancies due to all sources of error five transits were set up and the elevation obtained by stadia and vertical angle of three points at distances of about 100, 200 and 150 ft., respectively, and at vertical angles of about 5° , 10° and 15° , respectively. Independent readings were taken by from 20 to 30 students at each transit, and the maximum discrepancy between the elevation of each point as found by the stadia and as found by spirit leveling is shown in the following table.

TABLE VI.
MAXIMUM DISCREPANCIES BETWEEN ELEVATIONS FOUND BY THE STADIA
METHOD AND ELEVATIONS FOUND BY SPIRIT LEVELING.

	Angle= 5° , Distance=100 ft.	Angle= 10° , Distance=200 ft.	Angle= 15° , Distance=150 ft.
Transit No. 1.....	0.48	0.81	0.77
" " 2.....	0.20	0.60	0.49
" " 3.....	0.23	0.73	0.73
" " 4.....	0.30	0.32	0.86
" " 5.....	0.32	0.85	1.13
Mean of Maximum...	0.34	0.68	0.80

The inferiority of transit No. 5 is again apparent. Since each value given is a *maximum* discrepancy, all the values are greatly in excess of the *average* discrepancies likely to occur in practice. As a matter of fact the greater number of discrepancies were more nearly like those in Table V, and in many cases were much less. The values in Table VI, however, showing the stadia method in the worst possible light, indicate the value of the method, especially for such work as taking contour elevations in topographic surveying, where, of course, it is most used.

The object of the tests described in this paper was to determine the maximum errors of single observations under unfavorable conditions. When a number of observations are combined as, for example, in running from station to station, errors are largely compensating and the total error is correspondingly small. Many examples of extremely accurate work in stadia surveying have been recorded. Thus, for instance, in the *Engineering News*, June 28, 1900, very complete comparisons of stadia and tape measurements are given where the degree of precision varies from 1-1660 to 1-2500. Discrepancies in elevations between stadia and spirit leveling, taken at random from the many results given, are 0.04 ft. for a line 2000 ft. long, and 0.49 ft. for a line 29,580 ft. long. It is to be noted, however, that in this survey (Oswego Mohawk Ship Canal Route) the ground covered was favorable for leveling operations.

Professor Smith of the University of Wisconsin in a series of tests to determine the effect of "differential refraction," (see *Engineering News*, June 6, 1895,) secured some interesting results which indicate how the degree of precision can be greatly increased in stadia surveying by taking certain precautions in determining the stadia interval. The stadia tests described in this paper were made in order to determine what degree of precision may be expected at the other extreme, when no unusual precautions are taken, when the instruments are not of the best, and when the observers are not expert in the use of the stadia method.

THE HIGHWAY BRIDGES OF THE NEW HAVEN IMPROVEMENTS.

By C. L. Slocum.

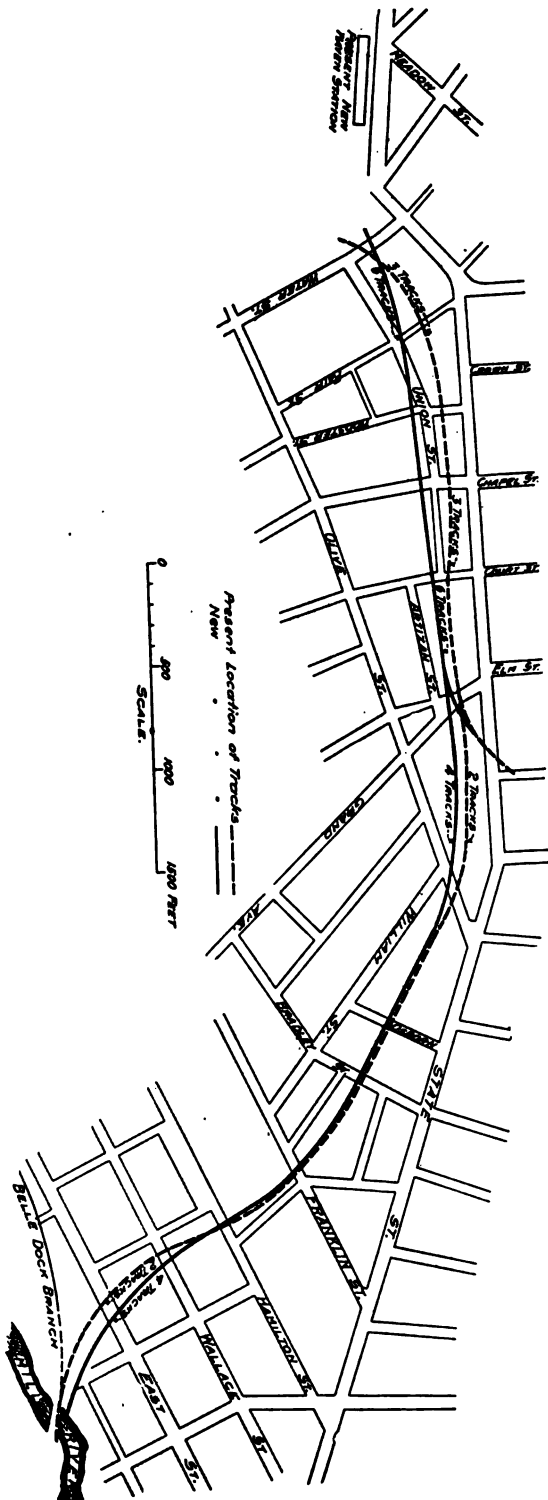
The city of New Haven has been aptly described as the throat of the New Haven Railroad System, for it is here through "The Cut," or depression through which the railroad passes, that traffic converges for western points or diverges by various routes for the east. In times past this badly congested throat has been subject to inundations, especially in times of high water and heavy rains, being in close proximity to the harbor front, and in elevation a little above high water level in the Sound, and below the water table of the surrounding parts.

Some thirteen or fourteen of the city's streets pass over this depression with steep approach grades; ten of these bridges only allowed, under the old arrangement, from 14' 2" to 14' 6" clear headroom for trains. The old bridges barely cleared the usual run of cars by a few inches and frequently larger cars had to be sent around by indirect routes to reach their destination.

The westerly portion of "The Cut" improvement is in the neighborhood of the wholesale district of the city, where heavy trucking and congested street traffic are most frequent, consequently as to whether the grades of the bridge crossings were more or less was rather a live and pertinent question with the commercial interests of the city. In the new construction the grades have been adjusted to easier percentages.

With the rails frequently below water and the raised bridges hindering and embarrassing heavy street traffic at all times and especially during the winter, what could be evolved for a new highway bridge that would more readily facilitate highway traffic, with easier grades, and at the same time allow railroad traffic underneath ample room. In keeping the street grades approximately the same and depressing the tracks, it was at first thought that 10 feet clear headroom would have to suffice on account of the uncertainty of the drainage of

PLAN OF OLD AND NEW ALIGNMENT SHOWING STREET CROSSINGS.



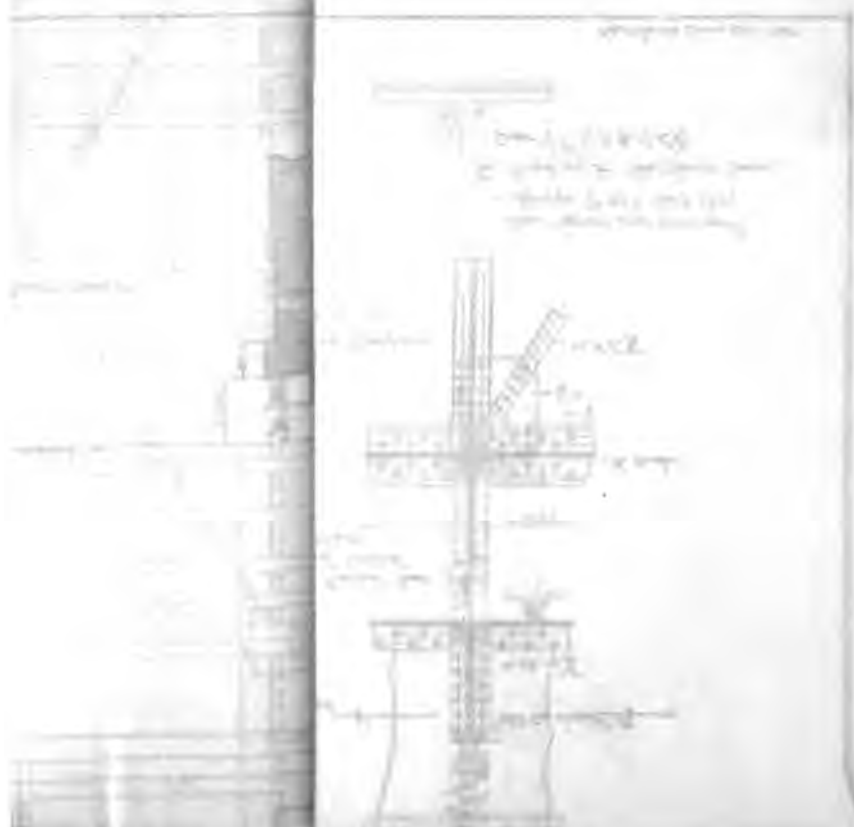
"The Cut," but under later studies under the supervision of Mr. E. H. McHenry, Vice-President in charge of Engineering, it was finally decided to ease off the former objectionable street grades by lengthening the approaches, and depress the tracks enough to allow a bridge of sufficient depth for ample strength, and to permit 18 feet of clear headroom. A carefully designed system of drainage for "The Cut" makes these highly advantageous changes possible and safe.

Three types of bridges for the highway crossings have been employed in connection with this work. (1) Plate girders. (2) Riveted trusses. (3) A series of reinforced concrete arches.

The bridges at Osborn, Bradley, Franklin, Hamilton, Wallace, and East Sts., representing the first type, consist of plate girders, spanning four tracks between concrete abutments. These girders support steel floorbeams and sidewalk brackets carrying the roadway, sidewalk and fence, respectively. The roadway door is made up of 5 inches of plank, the wearing surface of 2-inch spruce being supported by 3 inches of hard pine, all in turn carried by 6x14 inch hard pine stringers resting on the shelf angles of the floorbeams. Two-inch spruce plank on 4x12 inch stringers of hard pine carry the sidewalk on the brackets.

These crossings measure in the shortest width about 61 feet, making the bridges in total length over all vary from 63 to 75 feet, depending upon the angle of intersection between the centre line of street and the centre line of location. In width they varied from 43 to 75 feet between street lines. These widths consisted of the roadway and two sidewalks, the roadways varying from 26 to 45 feet wide and the sidewalks from 8 feet 6 inches to 15 feet wide. The widths of the top flanges of the girders were taken out of the sidewalk widths, in other words, the girders were on the curb lines. The widths of the gas and water pipes were at the expense of the roadway width.

As to what could be best done with the water and gas pipes to be carried over these bridges required some little study. The most graceful and economical way was to make the roadway wheel guards of abnormal size and enclose the pipes in them. A 2-inch plank box serves as ample protection for the mains and at the same time makes a suitable wheel guard.



A grave consideration of aesthetics was not made : design of the fence, although much grace could have added to all these structures if fence of another type have been used. The type of fence is outside of the jurisdiction of the railroad and was what the Engineering Department of the City of New Haven wanted. In defence of a high fence it can be said, however, that besides affording protection against frightening horses it makes the least attractive for loiterers and idlers.

The general and distinctive features of this type of bridge are seen from the inset sheet of Bradley St., which is the exact plan. The picture of Wallace St. gives the appearance of this type of bridge during erection.

These bridges, as well as the bridge work as a whole, are designed according to the standard practice of the New Haven and Hartford Railroad Co., or the best practice today. Economic depths for the floor systems of these bridges could not be considered. The least depth possible was in all cases to proportion the bridge floor.

The erection of the plate girders was accomplished by a pole derrick, the girders being swung over into position Sunday, while one track was in use, except that Wallace St. girders, being entirely on new alignment, were set at no particular time.

The East St. bridge is by far the heaviest of the plate bridges, containing some 245,000 lbs of steel and 44,000 lbs of lumber. Its floor is designed sufficiently strong for a track trolley crossing. Bradley St., representing one of the lighter plate girder structures, has about 92,400 lbs. of steel and 28 M. of lumber.

The abutments for all the bridges are of concrete, and the masonry of the entire improvement. They are of the same construction and design as the retaining walls, parapets and bridge seats. Making the face of the bridge abutments plumb and bringing this face out a few inches from the side or adjacent walls, as is customary, is perhaps better from the standpoint of appearance, in breaking the monotony of a long continuous retaining wall, but when the abutments are on the same rearward slope, or batter, of the retaining wall, you have uniform construction.



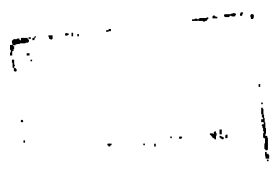
Bridge No 207 Hartford Div
For Olive Street, New Haven, Conn:
Over N. Y. N. H. & H. R. R.
3 coles $2\frac{1}{2}$ " and $2\frac{1}{2}$ " x 15'

Order N. Y. N. H. & H. R. R.

300/000 $\frac{1}{2}$ inch $\frac{1}{2}$ inch $\frac{1}{2}$ inch

St. Louis *August 11th 1892*

of 1892. New Haven, Ct. 1892.



pressure are nearer the middle of the abutment section. The body and foundations of the abutments are of a 1-3-5 mixture of concrete, the bridge seats and parapets 1-2-4 mixture. It has happened to good advantage that the bridge masonry has been well-seasoned before receiving the superstructure. The bridges already erected which cross the old alignment rest on blocking to afford ample clearance for present temporary requirements, but when the tracks are lowered to their final bed the steel work will be lowered to its permanent position.

The Berlin Construction Co. of Berlin, Conn., are the contractors for the bridges at Osborn, Bradley, Franklin and Hamilton Sts. Milliken Bros., Inc., of New York, built the Wallace and East St. bridges.

The structure to be erected at Olive St., riveted trusses, represents the second type of highway bridge used in this work and is the only one of its kind. Here rather unusually difficult conditions exist for a bridge. The centre line of location is on a 4 degree curve. The tracks, before reaching this crossing, start to converge from 17' 0 feet centres to 13' 0 feet centres beyond. The intersection angle between the centre line of street and the tangent to the centre line of location makes a sharp angle of 31° . The two inside pair of tracks are not concentric with the outside pair, nor is either pair concentric with the centre line of improvement, in other words, three distinct curves occur at this point. The calculations for distances and intersections were very difficult. Analytic geometry had to be resorted to instead of the usual trigonometrical methods. These computations were supplemented by careful and precise layouts. The abutments being concentric with the adjacent pair of tracks, are non-parallel and dissimilar.

In this design, any attempt at symmetry was out of the question on account of the large and different end skews. There are some few similar parts in this bridge but in the main it is a collection of differences. A double intersection Warren truss was used here on account of its stiffness and rigidity. The skews, being 50 ft. at one end and 61 ft. at the other, necessitated portals of rather unusual length. The end panels of the trusses were made alike to avoid making warped surfaces of the portals, and with this exception this bridge, perhaps, has all the complications credited to bridge practice. The trusses being dif-

ferent in length and necessarily unlike in arrangement of panels. For four ordinary sets of bridge computations were required to find the maximum stresses. The street surface and the floor of this bridge are of the same materials and construction as the floors of the plate girder bridges, and what has already been said about their construction and arrangement of pipes can also be said in the case of this bridge. This bridge was so designed that the floor could be renewed without disturbing the truss work, the floorbeams, in other words, being hung from the posts or short suspenders. The usual longitudinal camber of 6 inches is given the floor for efficient drainage, meaning that the trusses being at the same elevation, the floorbeams were suspended at different elevations, giving the floor the necessary drainage curve. This curve is parabolic for this bridge as well as for the plate girder bridges, except that in the case of the girder bridges the girders were cambered in the form of a parabola. A 3% approach grade at the Grand Avenue end of the bridge enlarged these different floorbeam heights somewhat. As will be seen from the inset sheets of the contract designs, the bottom chords or trusses were entirely above the floor away from the effects of the locomotive gases. These conditions made the ends of the trusses relatively very high, requiring high shoes with suitable stiffening struts from the chord to assure even effects from contraction and expansion on the bases or rollers. The middle diagonals of the trusses figured rather light stresses, the sections of which are increased to afford ample rigidity. This bridge, the heaviest of all the street highway structures, has about 320,000 lbs. of steel and 60 M. of timber in its make-up. It will be erected on falsework consisting of timber bents erected between tracks, carrying steel and timber stringers, while the tracks are in use underneath. The concrete bridge seats and masonry of this bridge are the most difficult to build of all the steel bridges. Milliken Bros. of New York are the contractors and builders of the superstructure.

What has been just described represents all the steel highway work in connection with this improvement.

By far the heaviest portion of highway construction is the third type of bridge, consisting of a series of reinforced concrete arches, each arch spanning a pair of tracks. This viaduct type

of construction was used at Fair and Union St. crossing, where four pairs of tracks are spanned. Similar construction will be used at Crown, Chapel, Court Sts. and Grand Ave. Piers between pairs of tracks had to be used in all these street crossings because this portion of the city and "The Cut" are nearest high water in elevation, and more depth could not be taken for a structure of greater span. These streets gave the most concern on account of their already steep approach grades, which started flat and raised suddenly. Here 6% and 8.8% grades will be replaced by 3% grades. These structures, one of which, Fair and Union St. crossing, is now nearly complete, have all the advantages belonging to reinforced concrete construction.

Several studies and methods of flooring these crossings were considered under the direction of Mr. McHenry, Vice President; all but one were rejected because of the difficulty in affording free and easy egress for the smoke and gases. Any construction similar to or like eyebeams and jack arches that would, in any way, form pockets for the gases, was considered comparatively short-lived and expensive in maintenance. Some form of a smooth arch offered the readiest solution to these requirements. What was finally evolved was a flat three centred arch which conformed to the best advantage to our double track clearance diagram. While practically nothing was gained in depth of structure in using the flat arch in preference to the other methods of spanning a pair of tracks, the arch form best facilitated the ready egress of gases, so that a train, in passing through, practically ventilates or draws out after itself its own smoke and gases.

The permanent qualities of this kind of masonry are evident to all of us who now realize that we are just entering the reinforced concrete age. The series of arches for these crossings not only afforded a practical solution to the difficulties encountered but gave at the same time a far more comely and graceful bridge.

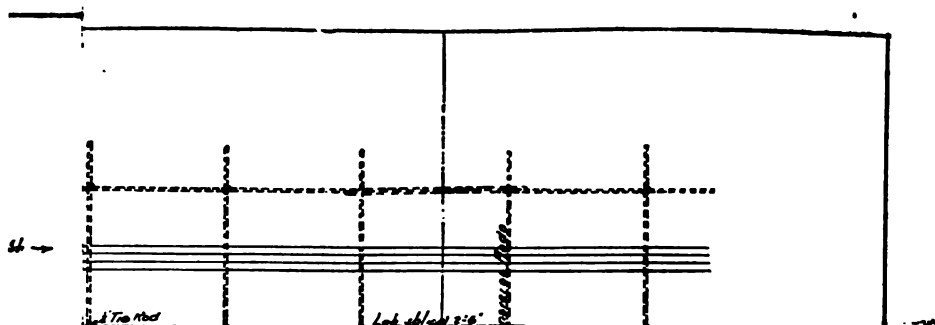
Essentially this reinforced concrete construction consists of embedding steel elements or units in concrete. The elements or units are of such form and dimensions and so placed in the concrete as will most adequately afford the greatest strength to the given shape. In this bridge work old track material such

as abandoned rails, fish-plates, and bolts, railroad scrap in other words, is the given material for reinforcement. Sufficient new material, in the shape of rods, bent plates, bolts and lacing, is added to make up the fabricated units and to bind all into a frame and mesh work. Reference to the inset sheets showing these various steel units will indicate how the reinforcement was arranged in the concrete.

An arch unit, it will be seen, consists of a rail in its natural position following the extrados of the arch, and within 3 inches of its surface bolted at the crown to another rail which is inverted and which follows the curve of the intrados and about 3 inches from its surface. Where the rails separate, bent plates or lacing is inserted which is bolted to the flanges of the two rails, making a truss frame or unit. In short, all arch units are of this construction. The arch units, it will be seen, are spliced into the pier or abutment units. A pier unit is made up of a vertical rail to which, at fixed heights, are bolted short pieces of rail to which are spliced the rails of the arch unit. Where the arch units are next to an abutment or the end of the bridge they are spliced into the abutment units or anchor frames. The abutment units in shape follow the exterior shape of the abutment. The lacing, of bent plates, of the constituent rails makes the unit or frame. In review and speaking generally, all units are composed of two rails except the pier unit which is composed of three pieces, and in shape follow the exterior surfaces of the particular part in which they are embedded.

In this work the main item of cost to be studied is in the work of fabrication of these rail trusses or units, consequently full length rails were used as far as possible.

Theory and practice tell us, convincingly, that the finer the distribution of metal in the concrete the more homogeneous the reinforced concrete; but in the use of these large steel sections other advantages accrue and much is gained in stiffness. When the reinforcement sections are large, shorter and easier methods in erection can be used where falsework of the usual kind cannot be employed. These advantages were considered in the use of large sections. If it is found necessary, these unit frames and reinforcements are of ample strength, size and stiffness to support the arch lagging. Those of you who saw the completed reinforcement of Fair St. will readily admit that





it has considerable sustaining powers within itself, without the concrete. Arches of this type could be erected in perfect safety over tracks in constant use. However, where possible, a conservative course has and will be pursued, employing the usual falsework.

It is a favorite method of some European designers and constructors to make the reinforcement large and strong enough to support the necessary lagging and adjuncts. They claim, and it seems plausible, that the saving in the cost of forms is far greater than the increased cost of the added steel area necessary for self-support. A disadvantage in using such large sections is that the areas are not elastic; in other words, where smaller areas of steel would have sufficed, the large areas had to be used for uniformity of construction.

This unit truss construction is properly continuous along the entire length of the structure, making easy a careful placing of the reinforcement. In the use of large sections, such as the fixed rail section, constant care must be taken to have as few kinds of frames as possible. Each new kind means a new shop template and added cost. Small rods lend themselves to any variety and set of circumstances without much trouble, being readily bent and twisted to suit particular purposes.

In railroad work no material is more readily at hand or cheaper than old rails and fittings, and if the railroad shops could have fabricated this reinforcement as was originally intended, it is extremely doubtful if more economical reinforced concrete could be built with the same large measure of reserved strength in such large sections. Considerable difficulty was experienced in obtaining old material uniform enough to go together easily in the field. There are five different makes of rails in the Fair St. bridge. Much time was lost in adjusting and hammering obstinate fish-plate connections into place.

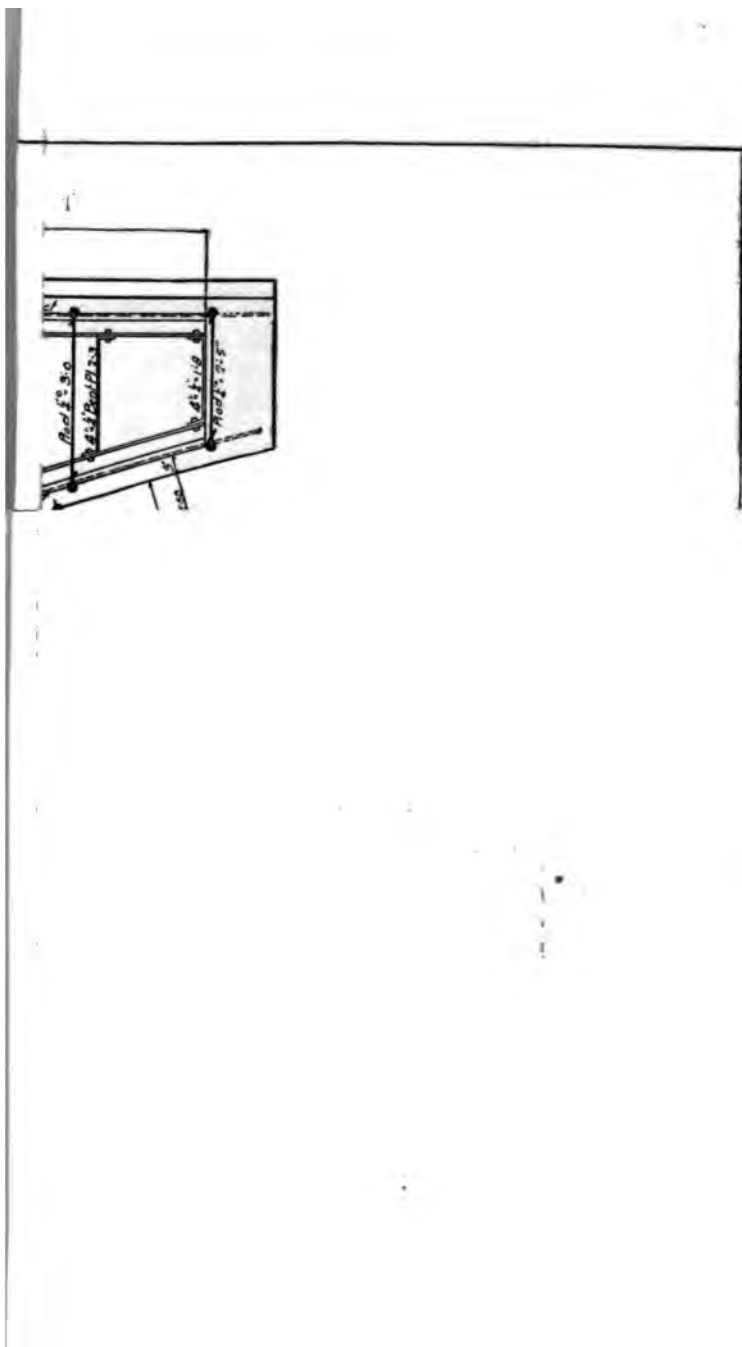
In physical characteristics the rails varied very much. Before the actual work of the fabrication of the reinforcement commenced, some experiments were conducted to see if the material intended for use could be bent cold to the severest curves required. Unfortunately, the first few rails bent had exceptionally good elastic qualities and were easily bent to the curves of shortest radius without any signs of cracking or fracture of the metal at the bending points. It was concluded that this

material could be handled cold at the desired curves. When the actual work of fabrication commenced the rails cracked and snapped off short under cold bending and after trying various kinds without success, resort had to be finally made to heating the rails before bending them.

No refinements were attempted in bending the rails to the curves shown on the drawings. The sections being large and cumbersome to handle, 3 inches leeway from the reinforcement to the surface of the concrete was allowed for difficulties in exact bending. In the erection of the Fair St. reinforcement, the distance of the rail reinforcement to the surface of the concrete varied from 3 to 6 inches, but was never allowed to be any less than 3 inches.

As to the spacing of the reinforcement units, 3 feet was the prevalent spacing in most of the construction; in places it was slightly less than 3 feet and sometimes 4 feet. For instance, at Fair St. the alignment is on a 4 degree curve, consequently the reinforcement units had to be placed in radial lines to avoid an endless variety of units, had it been attempted to run the rail trusses parallel to the centre line of the street. This is the reason why there are projecting corners from the sides of the Fair St. bridge. The details of design of these corners and overhangs are shown on the inset sheets.

As to whether the reinforcement trusses are spaced 3 feet or some other distance apart, necessitated some little theory and computation. As an elastic arch with its bending moments far less material is required than is used. The nature of the reinforcement, its arrangement and possible uses, suggested computations on the basis that each arch consisted of two cantilevers carrying a small suspended span in the middle. This method of computing the stresses in the constituent materials was considered the best under the circumstances. For loading, the heaviest concentrations, as steam road rollers and trolley cars, were considered in the design. Whether the span is considered as a composite beam or an arch, the rails in the extrados may be considered as in tension while the rails in the intrados as members in compression. The material for tension members is selected from a promiscuous lot and splices were made and adjusted accordingly. Where the joints in the compression members or intradosial rails were open and a poor fit could



not be helped, babbitt metal was poured in to insure tightness and a perfect transmission of the forces. In the intrados, splice plates are bolted to the lower flanges of the rails in an endeavor to develop as much of the rail section as possible in tension, in addition to the regular fish plates and bolts.

Between the rail trusses, following the intrados and extrados, are inserted $\frac{1}{2}$ -inch rods, spaced about 1 foot centres longitudinally and 2 ft. centres transversely. The upper and lower points of crossing are tied in by $\frac{1}{4}$ -inch vertical round rods. The entire reinforcement made a compact rigid steel skeleton.

As can be seen from the inset sheets, the old rail trusses are in convenient shipping and handling sizes.

The crown thickness is 14 inches, 8 inches being allowed for two depths of rail which varied somewhat with the kinds, plus 3 inches of concrete covering on each side. Bitulithic paving 3 inches in thickness is the wearing surface of the roadway. This is laid on the rough top of the solid spandrel arches.

As can be seen from the nature of the construction, 14 inches crown thickness does not permit the usual calibre of water and gas mains or a great number of telephone conduits. Nothing of this nature could be inserted in the reinforced construction. The only resort left was to insert all the necessary pipes and conduits for present or future use, in as deep a sidewalk as could be made.

The sidewalks are all given a 10-inch gutter depth and sloped back to the coping of the bridge at the rate of $\frac{3}{8}$ of an inch to the foot. All pipes and conduits are conveniently laid in the material composing the sidewalks and are in a good measure accessible for repairs.

The cross section of Chapel Street shown on one of the inset sheets specifies the kind of material composing the walks and the arrangement of the pipes and conduits in them. Incidentally, this section also shows the arrangement of the reinforcement through the crown of the arches and through the piers.

A section of a proposed curb is shown, which has been used with some degree of success in several of our large cities. Sometimes an angle is inserted in the corner to prevent chipping. The wearing qualities of this kind of curb seemed doubtful as compared with the usual granite curb, so the latter kind will be used in its place.

Details of the standard board fence used in the improvement are shown on the same inset sheet.

The nature of the foundation material at the different bridge sites and the heavy superimposed loads will make necessary in most cases the use of piles in the pier and abutment foundations. The driving of piles is the first operation in preparation for the foundations. They are spaced about 3 feet centres and figured as being safely worth about 15 tons. The foundations in concrete are then brought up to the lowest elevation of the reinforcement. Then the falsework is commenced. No steel of whatever description is placed until the completion of the falsework.

In brief, the forms consist of bolted plank trusses of proper curved form spaced some 4 feet apart carrying 2-inch plank lagging on top. In section and construction this form resembles a large sewer invert. The curved forms are supported on timber bents composed of 12x12-inch verticals spaced about 4 feet apart. Three bents to the span are used, one being placed at the crown, the other two at the ends. These bents are braced in both directions by 6x2-inch diagonal strips. The arch trusses consisted of 3 strips of 10x12-inch plank in short sections shaped to the curve of the intrados, and 2-10x2-inch planks in suitable lengths for the straight bottom chord. 2x6-inch plank composed the diagonal struts between the chords. The bents carrying the curved forms rested on sills, between which and the bottom timber of the bents were inserted oak adjusting wedges by which the falsework could be adjusted to any desired elevation. Half inch bolts are used in assembling the different truss members. 20d wire nails are used in nailing down the lagging plank to the arch trusses.

In the building of the Fair St. bridge, this arrangement of falsework has served its purpose adequately. The arch forms were set an inch higher than the figured elevations to provide for any settlement. The forms and supports were so made as to be available for similar arches for the other streets.

The falsework in place, the placing of the rail trusses and units commenced by resting them on small 3-inch blocks on the lagging, allowing the specific distance from the surface of the concrete. Adjusting the rail frames and splicing them is by far the most tedious part of the job. At Fair St. this

work proceeded slowly on account of the variety of material. The old fish-plate holes did not occur uniformly and much trouble was encountered in avoiding the interference of bolt heads. This experience at Fair St. demonstrated the need of more uniform material for the other bridges to properly facilitate the work. The placing of the reinforcement and its



FAIR ST. FALSEWORK AND REINFORCEMENT IN PLACE.

detail consumed most of the time in the construction of the Fair St. bridge.

After placing and connecting up the rail units along the entire length of the bridge, the abutment rail units were concreted in, holding the rail work at the two ends firmly in place for the accurate placing of the rod mesh work. All intersections and crossing of reinforcement were tied in by turns of small wire.

Placing the concrete proceeds rapidly when started. The materials for the concrete work of the Cut improvement are

most possible. The best clean sharp sand and gravel is found throughout the necessary excavation. Stone of good quality, composing old bridge seats, piers, and walls of the old alignment, is crushed at convenient points for the concrete. In the concrete of the reinforced bridges a 1-3-5 mixture is used in the abutments and piers, which are completed first. The arch concrete consisted of a 1-2-4 mixture with the stone in size to pass a $\frac{3}{4}$ -inch ring. All joints, or the ends of a day's



FAIR ST., ARCHES COMPLETED; UNION ST., TRIANGLE UNDER CONSTRUCTION.

work in concrete, are left rough and, if necessary, the next day are cleaned and moistened for the best bond. A wet mixture of concrete is preferred, which agrees with the best general practice. It has waterproof qualities.

Up to this date of writing, the bitulithic pavement has not been put down; moisture in the form of water, snow and ice, has covered the Fair St. bridge. An occasional inspection of the intrados of the arches gives no evidence of any percolation through the structure. So it may be safe to assume that the concrete structure in itself is waterproof. Bitulithic paving

and the composition of the sidewalk surface afford other ample and sufficient waterproofing for the street surface.

Exposed side surfaces and other parts where the forms could be easily removed when the concrete was green, were rubbed off smooth by a hand rubbing board with sand and water. Inaccessible parts, such as the exposed intrados of the arches, received an inch layer of cement mortar before the concrete was placed, while the sides of the piers and abutments were spaded. Exterior surfaces at Fair St. have come out satisfactory.

The Fair St. arches and the street surface of the bridge follow a longitudinal parabolic curve. It is about 150 ft. long and 40 ft. wide with a roadway 26 ft. wide and two sidewalks, each 7 ft. wide. It contains about 1550 cu. yds. of concrete and 350,000 lbs. of reinforcement. This bridge and the other reinforced concrete bridges will have the standard high board fence, but it is hoped when this portion of the New Haven Railroad system is electrified and the noise, smoke, and dirt are mere recollections, this fence which we will now have to look at with regret, will be replaced by a neat and artistic reinforced concrete balustrade, a fit associate for so comely a bridge.

Messrs. C. W. Blakeslee & Sons of New Haven are the contractors and builders of all the reinforced concrete highway bridges as well as all other masonry, necessary excavation relating thereto, and work in connection with this improvement. The Yale Safe and Iron Co. of this city are the fabricators of the rail reinforcement. The Aberthaw Construction Co. of Boston supplied the rod reinforcement. Warren Bros. of Boston will lay the bitulithic paving.

All the engineering questions were handled by Mr. E. H. McHenry, Vice President, in charge of Engineering. Mr. Edward Gagel, Chief Engineer, and Mr. W. H. Moore, Engineer of Bridges, under whose supervision this bridgework was designed and is being constructed, are members of this society. The writer is Assistant Engineer in charge of the design of the bridges of the New Haven Improvement.

THE NEW HAVEN CUT.

By John F. Trumbull.

In these days of increased demand upon railroads and with a future requiring still greater facilities, plenty of room and some to spare must be had at all important terminal and junctional points where a prompt and safe classification and movement of passenger and freight traffic is necessary. The old New Haven Cut, which amply satisfied former traffic demands, does not now begin to afford these common and essential facilities of modern railroad operation. In brief, this is the reason for the railroad improvement now being carried on in New Haven.

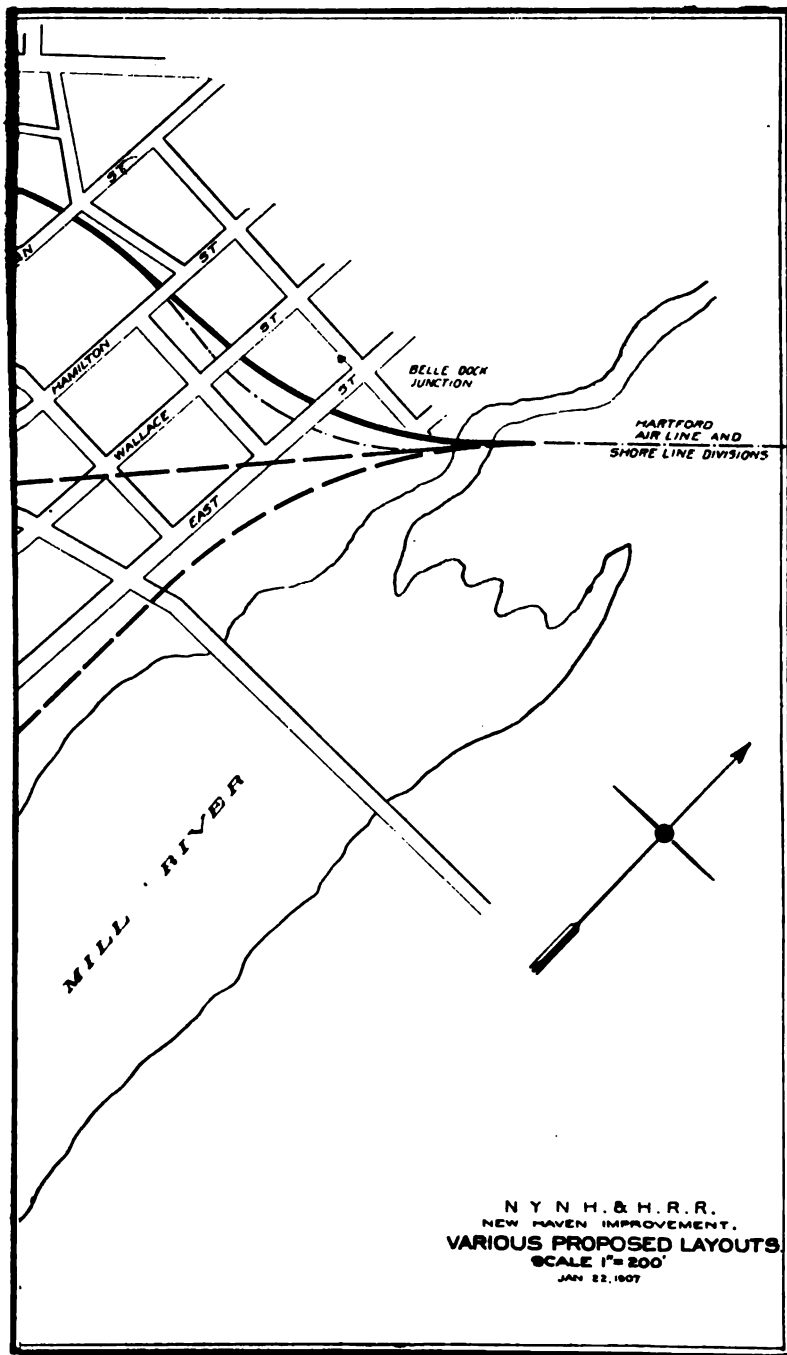
An average, taken from recent train sheets, shows that there are about 350 train movements through the Cut in 24 hours, including switching between Water street and Cedar Hill yards. East bound trains are occasionally stalled on the maximum grade and curve near the Belle Dock Junction, while west bound trains are frequently delayed by the congestion at the throat of Water street yard. When, as on a football day, three or forty special passenger trains must be handled in and out within a few hours, train movements are rather frequent. At such a time a slight hitch or delay is likely to modify seriously any plan which has been worked out for handling the traffic.

Considering for a moment the physical characteristics of the present Cut before passing to a brief description of the various plans for getting the railroad through New Haven, we see that it extends from the throat of the freight yard at Water street just east of the present passenger station, to Belle Dock Junction at Mill River, a distance of about 6400 feet. It contains, at present, two main line tracks extending the whole length and a third track from Water street to Grand avenue, for the Northampton Division. From Belle Dock Junction easterly, there are four main line tracks used by the Hartford, Air Line, and Shore Line Divisions. From Water street to Grand avenue the tracks are in the old Northampton Canal bed, and are a

number of curves, the minimum headroom being so small that it is impossible to send many of the large modern freight cars under the bridges. The worst curves in the Cut are immediately west of Belle Dock Junction, where a 5 degree reverses into a 7. The present Cut has a total curvature of 161 degrees. The maximum grade occurs on the reverse curve mentioned above. It is about 1.5 per cent.

Some of the plans which have been proposed for bettering these conditions are briefly described here, the layouts being shown on the accompanying map. The first plan, which was approved by the Connecticut Railroad Commission, was to parallel the old tracks with two additional tracks throughout the Cut. Increased headroom was to be obtained both by lowering the tracks and raising the street bridges.

Much opposition to this plan was developed in the city of New Haven, on the ground that the street grades, already objectionable, would be made steeper. A long period of discussion followed; the Railroad meanwhile investigating six other plans, with the understanding that any one chosen by the City would be acceptable. A summary of all the plans considered gives:

- 1st. The plan already mentioned.
- 2d. To follow the present location with the tracks on a structure elevated above the street crossings.
- 3d. To shift the tracks to the east and carry Union street on a steel floor above them.
- 4th. To abandon the present Cut and run from the present station along the water front to the Belle Dock Branch and on to a junction with the main line at Cedar Hill, the Belle Dock Branch being carried on an elevated structure.
- 5th. The route last described but with streets crossing over the tracks instead of under.
- 6th. To run straight across the city from the depot to Cedar Hill on an elevated structure.
- 7th. To follow the water front on a fill made outside of the docks to the Belle Dock Branch.

Plans four and five were backed by an offer of the Railroad to deed its present holdings in the Cut to the City in return for a right of way along Water Street where the Company did not own land, the City to pay the difference in cost between the two plans provided it was less than \$1,000,000.00; under the pro-

visions of the State Grade Crossing Act. The City refused to accept any of the above plans. To add to the joy of the occasion, parties unknown caused signs bearing the legend, "The Bottom Of This Sign Is The Height That The Railroad Co. Ask To Raise This Street," to be affixed to poles more or less distant from the site of the proposed work, in several places where no change was planned and above the heads of the passersby in some cases; the wayfarer thus being enabled to consider the prospect of the surrounding streets of the afflicted city buried under a fill of from three to seven feet as far as the eye could reach.



LOOKING EAST FROM ROOF OF MASONIC TEMPLE.
ARTIZAN ST. RETAINING WALL PARTLY COMPLETED SHOWING
CHANGE IN ALIGNMENT.

As time passed and no agreement was reached, the Railroad decided to go ahead with plan number one, which had been approved by the Railroad Commission. The City immediately applied for and secured a temporary injunction, but before the case was tried an agreement was reached between the Road and a Commission consisting of the Mayor and two Aldermen appointed by the Board of Aldermen; the Commission being unable to bind the City to pay any share of the construction

expense. A compromise was at last agreed upon, under the terms of which the work is now being done.

Under the accepted plan the tracks were moved some distance south of the old location for more than half of the length of the Cut. This was done in order to obtain lighter approach grades from State street, which runs nearly parallel with the right of way. It was undesirable to convert an extremely busy and almost level street into a series of humps at the grade run-offs, to say nothing of the excessive property damages due to added street elevation. In most cases it would have been cheaper to buy property outright than pay the estimated damage.

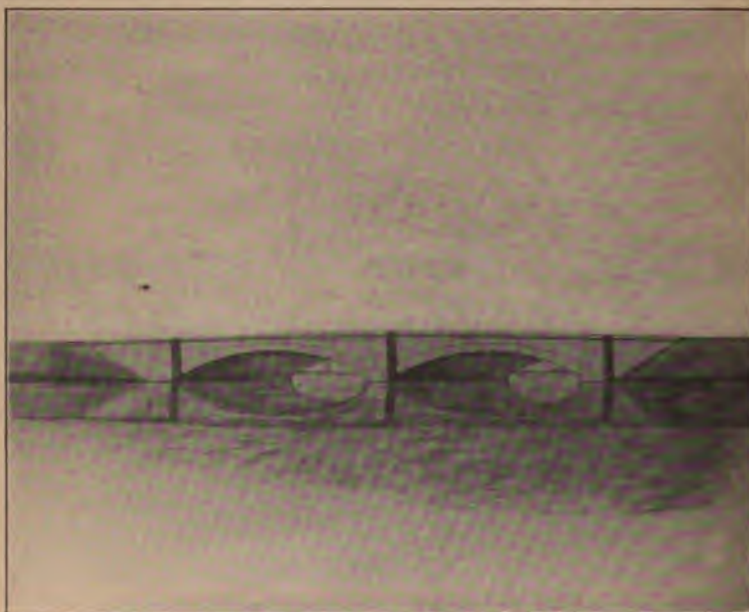


CURVED CONCRETE ABUTMENTS AT EAST ST. SHOWING CHANGE IN ALIGNMENT AND TEMPORARY BRIDGE.

Four main, and two Northampton tracks are provided, together with sidings giving access to various wholesale houses on State street. Maximum curves are 4 degrees with maximum grade of 0.73 per cent. The longest tangent is about 2000 feet, 33 degrees of curvature being eliminated by it. The new line is shorter than the old by about 300 feet, there being 161 degrees of curvature on the old against 102 degrees on the new. On the approaches to street bridges the maximum grade

is 4 per cent., the greatest elevation above the former street surface being 9.5 feet at Fair street. The greatest track depression is about 7 feet for 400 feet.

The highway crossings, going east from Water street, are carried on five reinforced concrete arch bridges, two tracks to a span, from 140 to 180 feet long; one Warren riveted skew truss bridge of about 140 foot span and 6 plate girders. The line crosses Mill River on a 6-track reinforced concrete skew arch of two 50-foot clear spans; Humphrey street extension, a little further on, being spanned by a plate girder bridge on a



SKETCH OF PROPOSED SIX-TRACK CONCRETE BRIDGE
AT MILL RIVER.

very sharp skew; these bridges will be described in detail by their designer, Mr. Slocum of the Bridge Department. In connection with the Humphrey street extension, the present Cedar Hill Station is to be replaced by a more modern structure on the opposite side of the right of way; as the space occupied at present is needed for additional tracks.

Returning now to the lower end of the work, the trolley tracks in State street between Chapel street and new Union

avenue are to be removed and carried above the present tracks in the Cut on a concrete viaduct crossing the streets at grade. This arrangement will surrender State street to team traffic and shorten the running time of station cars. On the south side of Chapel street a concrete, steel frame office building containing a trolley waiting room is to be erected over the proposed tracks.

Passing to the actual construction, we may roughly arrange the description under the following headings: Surveys, Excavation, Drainage System, Temporary Work, Concrete and Track Work.

Surveys.

Surveys were started in April, 1904, by following up a previous Center Line of Improvement run in several years before. This line was carefully reestablished and all P.C's.P, T's and P, I's referenced. It was then thrown up onto the street bridges, and intersected with the street center lines. Working from these lines, detail surveys were made, locating walls, buildings, tracks, poles, etc. On the streets all doors, windows, steps and area ways likely to be affected by gradé changes were picked up and all manholes, catchbasins, valves, pipe and conduit lines located.

Instrument work in the Cut was attended by much inconvenience due to the frequent passing of trains, vibration, smoke and the long stretches where there was not enough clearance between wall and train to allow a man to stand in safety. Lumps of coal of all sizes, dislodged from swaying tenders, were found to be quite unpleasant things to meet.

The final Center Line of Improvement ran over the roofs for nearly half a mile between Fair street and Grand avenue. It was established on the roofs and its length calculated, using data from previous lines on the ground. After the removal of buildings it was run through on the ground and measured. No appreciable error in direction appeared, while the measured distance checked the calculated within 0.03 of a foot. Buff and Buff transits were used and measurements made with 100-foot steel tapes without spring balances. All street lines and permanently useful points were carefully referenced and a double system of bench marks established and cross checked,

one system being in the Cut for use on track, foundations, etc., while the second was above on the streets at convenient points clear of disturbance. No accidents to field engineers while on track have occurred, everyone observing the rule not to stand on an empty track to avoid a passing train and by always locating which track an invisible approaching train is on. It may be running left-handed.

The next step was the removal of the one hundred and thirty odd buildings, ranging in size from frame sheds to six-story brick structures. Several brick houses were quickly torn down



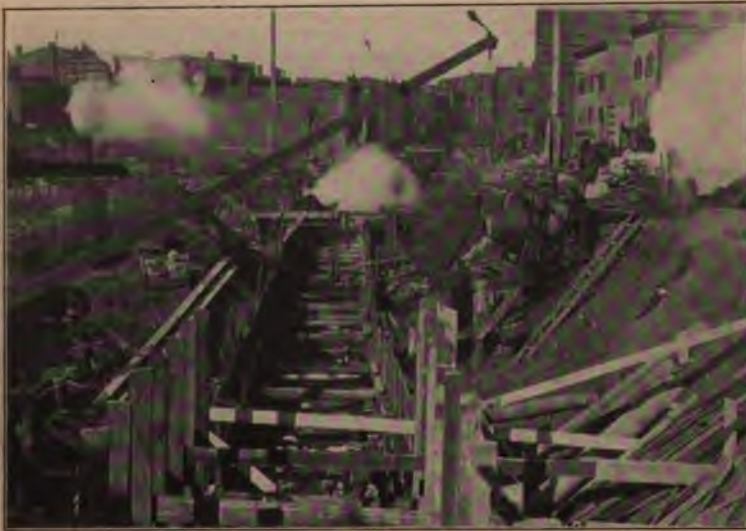
STEAM SHOVEL AT WORK TEARING DOWN BUILDINGS ON FAIR ST.

by the railroad steam shovel, when pressure on the wrecking contractor became necessary. One building, whose lower story contains the Improvement Engineering Office, still remains, due to the presence of a lessee in the upper stories.

While the removal of buildings was in progress, borings were made at points to be occupied by the more important structures. These borings brought up sand of various qualities and degrees of fineness from all depths down to 88 feet below mean high water.

Excavation.

About 350,000 cubic yards of excavation, of which about 200,000 have been removed to date, are handled by three of the Road's steam shovels, material being removed to the outskirts of the city and used for filling in trestles and widening fills. While most of the digging has been in sand and gravel, the shovels have been frequently delayed by old foundation walls and the soft wet ground, the new drainage system not being in operation. Regular traffic on the main line also prevented the prompt removal and delivery of cars. Under these conditions,



FOUNDATION FOR UNION ST. RETAINING WALL. STEAM HAMMER
DRIVING SHEET PILING IN BACKGROUND.

the best day's work for one shovel was 3000 cubic yards and for the three shovels 6000 cubic yards. Some of the abutments and retaining walls were started in trenches while the excavation was in progress, the core being removed later.

Drainage System.

Perhaps the most important problem on the work is that of securing adequate drainage. The sandy soil permits water to pass freely though it, while the ground slopes toward the Cut nearly everywhere except at the street crossings. The North-

ampton Cut also brings in considerable water. It was that a high tide and rain storm at the same time would flood the proposed depressed tracks unless pumps or some other means were introduced for removing the water. The writer has been on several occasions within the past two years and a half on the Cut, even the present tracks were submerged. The run-off was figured on the basis of maximum rainfall on frozen ground.

The proposed drainage summit is at Franklin street. From this point eastward there is a cast iron pipe line between the tracks draining by gravity into Mill river. From the summit westward to Water street, a similar pipe line has been laid, the



THE RESULT OF A HIGH-TIDE AND HEAVY RAIN IN THE OLD CUT
NEAR CHAPEL ST.

with a diameter of 16 inches, increasing to 36 inches. Concrete manholes (see p. 76) are located about 300 feet apart, each manhole being connected with a cross drain extending the full width of the Cut; small concrete receiving basins being located between each two tracks and at the foot of wall or slope. The main pipe descends on a grade of 0.06 per cent. to Water street, where the bottom of pipe is nearly five feet below high water, the harbor being about 1500 feet further on. The design of the pumping plant now being installed at Water

[REDACTED]

[REDACTED]

[REDACTED]

N.Y.N.H.&H.R.R. ⁹
NEW HAVEN IMPROVEMENT. 466
PROPOSED PUMPING PLANT
AT WATER ST.
SCALE $\frac{1}{4}'' = 1'$
NOV 5, 1906

VED:

CHIEF ENGINEER.

FOURTH VICE PRESIDENT.

was suggested by Mr. E. H. McHenry, Vice President in charge of engineering.

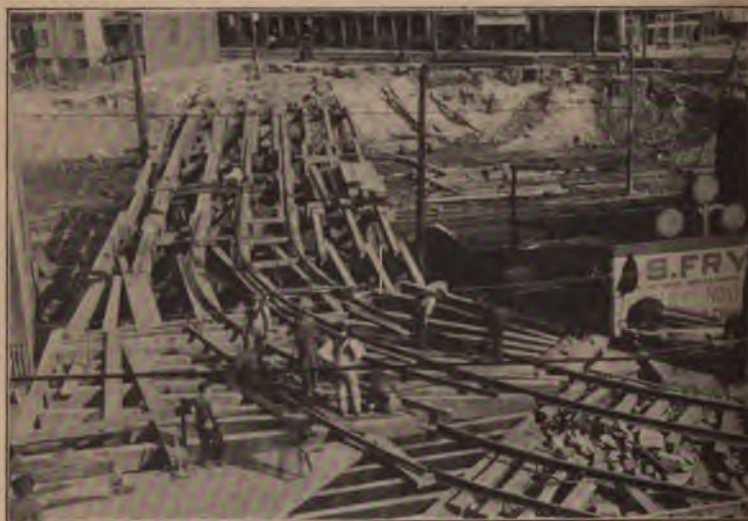
The pipe line enters the pumping chamber by a branch from the main line. This branch, with a muck rack at its head, is formed in an underground concrete chamber containing two sets of self-acting tide gates just below the branch. The roof of the chamber is made amply strong for tracks to be placed over it and is pierced by suitable hatchways. Below the tide-gate chamber, in the direction of normal flow, the outlet from the pumps joins the main pipe line. In other words, a plan of this system forms a triangle whose base is the tide-gate chamber, apex the pumping chamber and two sides the inflow and outflow of the pumps. Normal gravity flow passes only through the base. The pumping chamber is of concrete and contains two vertical, submerged, bottom suction 15-inch centrifugal pumps of a normal capacity of 6000 gallons a minute each against a 10-foot head at 378 r.p.m., an occasional speed of 450 r.p.m. being provided for. The motor house is built on the walls of the pump chamber, and contains two 50 horse power, horizontal d.c. motors, connected by bevel gears to the pump shafts.

At low tide the flow from the Cut passes through the open tide gates and on to the harbor. Tide backing up closes the gates and turns the flow through the upper branch into the pump chamber. The motors are started by Cutler Hammer starting devices connected with floats so arranged that one pump starts at a different water level than the other. The whole arrangement is such that the pumps force the flow towards the harbor against the tide. The horizontal motors and bevel gears are used instead of direct connected vertical motors because no suitably formed and speeded vertical motors could be found, while submerged pumps are used to avoid suction and priming difficulties as well as danger of leakage in the suction pipe, it being desirable to have the working of the plant entirely automatic.

Temporary Work.

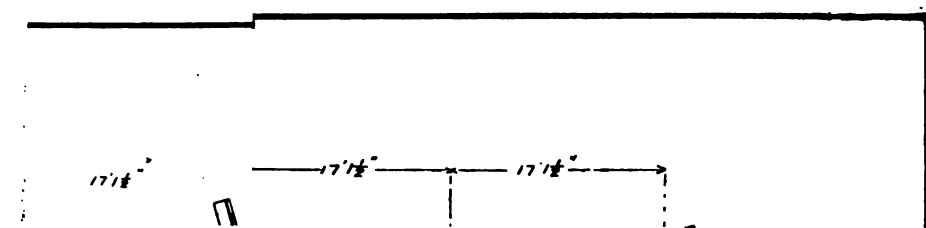
Considering for a moment the large amount of temporary bridge work, we see that much of it was only necessary because of the Road's agreement to keep alternate streets open

to traffic; except Grand avenue and Chapel street, which were to be always in service. These latter are the largest pieces of temporary highway construction we have. In all cases, bents were spaced to clear the pier, abutment, temporary and permanent track sites in so far as they could be foreseen, sufficient headroom for the passage of the larger steam shovels being also figured on. Chapel street is the only case where the temporary bridge had to be built before the excavation of the street. This was done by closing half the street width to traffic and driving pile bents through the street surface; these bents



ERECTION: GRAND AVE. TEMPORARY BRIDGE, TRACKS IN SERVICE UNDERNEATH.

were capped, stringers and trolley rails placed, flooring put on, and traffic turned on to the new structure; thus leaving the core underneath entirely free for excavation by steam shovel. All floors are on 8-inch by 16-inch y.p. stringers thoroughly tied together, drift bolted and spaced to accommodate the various spans. Trolley rails are spiked directly to these stringers and pipes are carried on floor plank projecting outside the fences. At some closed streets foot bridges have been erected as an accommodation to the public.



Hand-drawn diagram showing a vertical line segment.

Hand-drawn diagram showing a small, dark, irregular shape.



At Mill River the former stone arch bridge occupied part of the site of the proposed structure. A temporary run around trestle with plate girder channel span is in service at this point. In order to shift tracks on to the trestle without materially changing their arrangement at this rather important junction point, a complete new signaling and interlocking plant was installed, and traffic turned on to the temporary work a track at a time on a Sunday when trains movements are comparatively few. The old arch bridge was then removed, the keystones being drilled and blown out with dynamite. In several



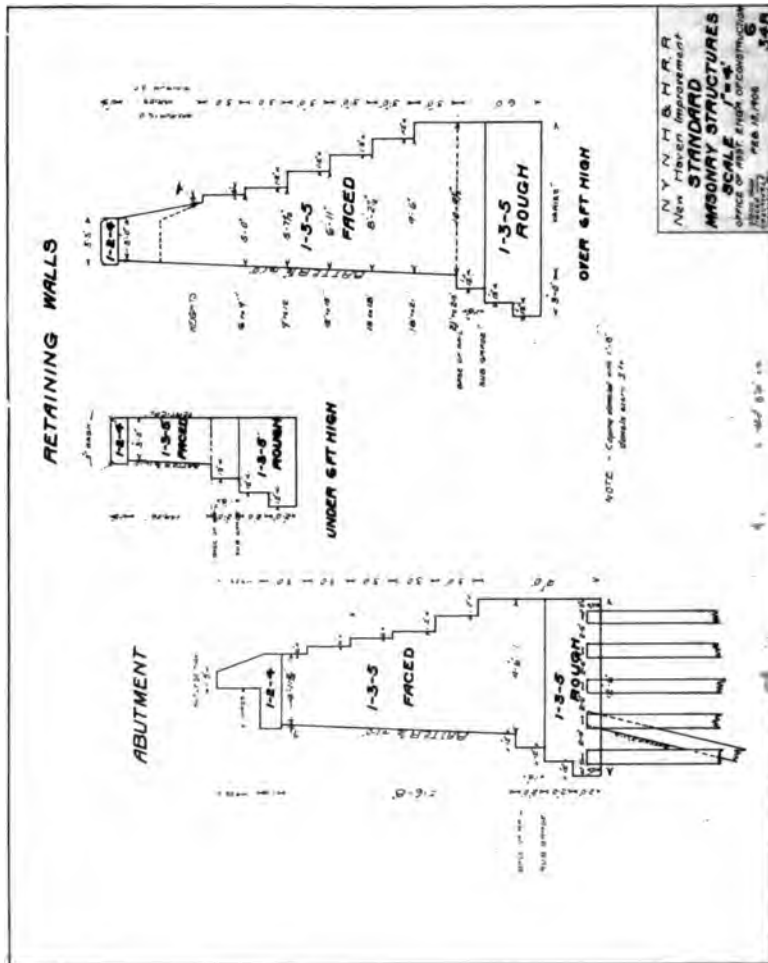
TEMPORARY BELLE DOCK JUNCTION AND PART OF SITE OF MILL RIVER BRIDGE. CONTRACTOR'S TRESTLE ON THE LEFT, FORMER STONE ARCH IN THE CENTER, TEMPORARY TRESTLE ON THE RIGHT.

cases, the strength of the mortar kept the arch haunches in place after the removal of the keystones.

Concrete.

The concrete on the Improvement, about 80,000 cubic yards, of which 20,000 is reinforced, is principally used in the retaining walls and abutments. Standard abutment and retaining wall sections are shown on the accompanying sketch, piles being put in pier and abutment foundations where necessary.

Good sand is obtainable at nearly all points on the work, while stone is obtained from the old walls and foundations. A 1: 3: 5 mixture is used for foundations and body; coping, bridge seats and parapets being 1: 2: 4. Good clean stone are



placed in the body concrete of walls and abutments, and the wall faces are finished by placing an iron shield 8 inches by 6 feet inside the forms and 3 inches from them, the 3-inch space being filled with 1: 3 mortar after depositing the body

concrete. The shield is then pulled up to the top of the body concrete and the process repeated. Immediately after the removal of the forms, the wall faces are scrubbed with wooden floats, so as to give as good a finish as possible. Expansion joints, finished on the face with a 1-inch V-shaped groove, are spaced about 30 feet apart. The most complicated piece of concrete work is encountered in Fair street bridge, where a portion of Union street crosses the east-bound tracks on a long skew supported by a number of concrete brackets of varying length and depth projecting from the abutment face, their



FINISHING THE FACE OF A SECTION OF RETAINING WALL.

under sides conforming to the intrados curve of the regular bridge arches. Olive street abutments present some unusual features. They are on a skew curve, and not parallel to each other or to the center line of improvement, this irregularity being due to a change in track spacing, which is worked out on the curve at this point. The various seats for truss pedestals and floor beams are at different elevations and the parapet is on a vertical curve, all of which complicates the calculations and layout somewhat.

been out of service at the same time because of the construction. It is necessary to complete the two south spans of the concrete bridges and turn traffic under them a track at a time, before their northerly portions, directly over the present tracks, can be built. This condition makes possible the combination of temporary and permanent bridge at Fair street. The situation is complicated by the fact that no two adjacent bridges reach the same stage of completion at the same time; necessitating a very crooked temporary alignment and several changes in



CURVED EAST ABUTMENT, OLIVE ST. BRIDGE. PRESENT TRACKS ON THE RIGHT, GRAND AVE. TEMPORARY BRIDGE IN BACKGROUND.

grade. Temporary and permanent track and some of the bridge and wall work are held up at the present time, as it is inadvisable to throw track down on to the low level until the permanent pumping plant is in operation.

The writer is indebted to Mr. C. R. Harte, member of the Society, for most of the pictures shown with this paper. The plans are from tracings in the Improvement Office, most of

which were prepared under Mr. Harte's supervision. The Engineering force at present consists of 14 men; Mr. M. C. Hamilton, formerly Engineer Maintenance of Way of the New York Subway, is in charge, Mr. J. M. Sullivan, Jr., takes the field work, and the writer has charge of the plans and designing.

LAYING OF SUBMERGED PIPES:

By Frederick S. Wardwell.

Early in the spring of 1904, the City of Stamford installed a system of sewerage for the east side of the city, necessitating an outfall into Long Island Sound. The specifications called for a "twenty-inch cast iron ball and spigot pipe," one half of which was to be laid from mean low water to a depth of five feet below mean low water at its off-shore end; the joints of the pipe, if floated, were to be of yarn and cold lead well calked; the joints of pipe which were to be placed singly were to be of cement and yarn, made as follows: A skein of yarn soaked in cement grout was to be calked in the joint, the joint was then to be filled with stiff cement mortar, then another skein soaked in grout was to be calked to the face of the joint, making a joint flush with the bell of the pipe.

As the specifications contained the following paragraph: "All material lost during the construction of the work shall be replaced by and at the expense of the contractor," I, doubting the adaptability of the above methods of making joints, asked the engineer in charge to permit me to use hot lead for the off-shore half and red lead and yarn for the in-shore half.

The problem presented was the laying of one thousand feet of twenty-four inch bell and spigot pipe, weighing one hundred and thirty-nine pounds per lineal foot, upon a sandy bottom, the grade of which was considered true enough without preparation.

After looking the situation over, I decided to lay the outer half, or that part from mean low water off-shore, in one section. We found a place upon the beach about a thousand feet from the site of the work, where the bottom was hard, fairly level and comparatively clean; upon this, at about three feet below mean high water, we laid five hundred and four feet of the pipe upon blocking, being very careful that it was level and straight.

All joints were made with hot lead and thoroughly calked as if for internal pressure. We took great care in making the

joints, as I had abandoned all previous plans of my own and those of others, freely given, for tying the pipe together to prevent the joints from pulling apart, should the sea start to run high during the floating to position.

This pipe, when both ends were closed, lacked approximately seven per cent. of buoyancy sufficient to float itself, but, in order to have a factor of safety, we attached in pairs one hundred and twenty-six empty oil barrels, the preparation of which I will say more of later.

No precaution was taken other than has been mentioned for keeping the pipe in alignment or surface while in transit. A wooden disk was made for each end; that for the spigot and off-shore end contained three two-inch auger holes plugged with ordinary pine plugs, to govern the air and partially govern the time of sinking; the in-shore end was made solid, but so arranged that it could be easily removed.

The morning of floating we started to fasten the oil barrels as soon as the tide had receded enough to allow the men to work. Our preparations were made fully an hour before the tide returned to the pipe, which was lifted at one end probably thirty seconds before the other, owing to the small waves striking that end first.

A day was selected when there was but little motion to the surface of the water and but little prospect of wind. Before the pipe was lifted, eight rowboats were attached at regular intervals by tow lines. When the pipe was clear from the blocking there was no trouble in towing it to place alongside of the guide piles that had been driven in alignment. After coming alongside the piles we had some trouble in getting the pipe in alignment, but finally succeeded.

My idea had been all along when designing the lashing for the barrels, that they would have to be cut away practically simultaneously. That idea, however, was erroneous, and in fact not desirable, as will be shown in illustrations Figs. 1, 2, 3 and 4 of the Shippan Point Land Company's pipe.

When dropping the pipe, men were placed at regular intervals with axes to cut the lashings; one man released the in-shore disk, and another man controlled the air valves or plugs at the off-shore end. All realized that an air trap at any portion of the pipe was liable to result seriously. We arranged, therefore,

to submerge the in-shore end before letting the air out of the off-shore end.

When word was given to cut away, it was high tide,—seven feet six inches of water at one end, twelve feet and six inches at the other. The pipe was dropped in just one minute. A friendly wind came up meanwhile and drove our released barrels up on the beach, but in later work we provided against the possibility of a wind from off shore.

The engineer in charge inspected the work at low tide, with the result that no part of the pipe was touched afterwards.

The other section of the pipe, that from mean low water to high water, was laid as would be any other pipe except that the joints were made up with yarn soaked with red lead and oil.

I attribute the success of this piece of work to: *First*, having the pipe so true to surface and in such a position, that when it was lifted, all parts lifted at practically the same time, as at no time afterwards is there so great a strain on the joints as when the little waves are just breaking on the beach and lifting the pipe; *second*, there being no defective joints or pipe; *third*, the perfect lashings for the oil barrels; *fourth*, having control of the air in the pipe; and *fifth*, having men that can and are willing to swim.

For the lashings for the barrels I had steel wire made, a No. 4 gauge, that would stand a tensile strain of eighteen hundred pounds and which proved fairly satisfactory; at the present time, however, I am using a No. 6 B and B telegraph wire, a regular stock article which stands the twisting much better.

In making lashings for the barrels, in order to get the lengths and shapes, we blocked up one piece of pipe a few inches from the ground and placed oil barrels parallel with the pipe, one on each side, so that the center of the oil barrel came a few inches above the center of the pipe; we cut a piece of wire just long enough to reach around one barrel under the pipe where it was twisted four times, then it was passed around the other barrel, leaving an eye in each end of the wire, in one of which there was spliced a $\frac{3}{8}$ -inch manilla rope. When the barrels were in position the hitch would be on top of the barrel and all on one side of the pipe. Two wire straps were required for each set of barrels. (This you will see illustrated in photograph Fig. 1.)

Before the day that the pipe is to be floated, these straps are placed upon half of the number of barrels that are to be used.

and all that is necessary to place them in position is to take two turns of the rope and half a hitch.

THE SHIPPAN POINT LAND COMPANY.

The Shippan Point Land Company's proposition, while containing only one hundred and ninety-two feet of pipe, was the more difficult. The location was exposed to almost every wind; about every large wave from a Sound steamer made itself felt before dying out upon the beach; the shore was very rocky, giving us much trouble to get a clear space, on which to lay the pipe before floating; the bottom had to be cleared by a



FIG. 1.

diver and the new pipe had to be connected with a pipe already in use. This pipe was Standard twenty-inch Ward joint, weighing a little over two hundred and sixteen pounds per lineal foot.

Nearly seventy-five pounds of lead was used for each joint. The pipe was laid precisely as was that for the outfall for the city, with the exception that the joints were run with hot lead and were not calked. The lifting and floating were very similar. In photograph Fig. 1, is shown the pipe just as it was starting to lift; in photograph Fig. 2, the pipe is about half way into position; in photograph Fig. 3, the in-shore end of the pipe has been brought into the guide frame at the end of the pipe, already placed, which is exposed at very low tide. A tackle block has

been placed at the in-shore end, and one at the off-shore end, fastened to a submerged boulder. A strain was taken upon both in order to bring the pipe into alignment.



FIG. 2.



FIG. 3.

In dropping this pipe, we first removed the disk at the in-shore end. One two-inch plug in the off-shore disk was taken out when the in-shore end was below the surface. We took more time to cut away the barrels from this pipe than we did those for the city's work. This enabled us to get the pipe into alignment, which was particularly hard, the wind having come up. We cut just enough barrels along the line of the pipe to let it sink slowly and afterwards sent down a diver to cut loose the barrels that went down with the pipe. We started to place the barrels under this pipe at 8 A. M.; the pipe was in posi-



FIG. 4.

tion and all barrels above the high water mark on the beach at one o'clock. On the next morning's low tide we found the in-shore end of the newly submerged pipe to be one inch away from the pipe in use, three inches higher, and two inches out of alignment. Two men made it fast and slipped the sleeve on in just one half hour. In only one joint did we find the lead beyond the bell.

SHELTON WATER MAIN.

The most difficult piece of submerged pipe laying that I ever had was that of the twenty-inch flanged joint pipe for the Shel-

ton Water Company, across the Housatonic River, just below the dam of the Ousatonic Water Company.

This submerged pipe had to stand a pressure of one hundred and forty pounds to the square inch; a trench had to be excavated from the bottom of the river from two feet to six feet deep; the material to be excavated mostly around clean gravel, containing not over twenty per cent. sand, under which was hardpan,—too hard for any ordinary dredging appliances to remove; we, therefore, had to dredge out to this hard bottom, making the pipe conform to it with specials. We expected to do the trenching with a jet from the water main, but owing to the mobility of the material, we were unable to make satis-



FIG. 5.

factory headway. After a two days experiment with the water jet in a four-foot cut, we had a space about fifteen feet long, fifteen feet wide and about eighteen inches deep. As this was making money in the wrong direction, we built a dredge upon oil barrel floats, as is illustrated in photograph Fig. 5. We were obliged to put a length of pipe in the trench as soon as it was excavated, in order to save it. Having this in mind when building the dredge, we used two floats instead of one, fastening them together, leaving a space of about three feet between them, through which, from an ordinary tripod derrick, we

lowered the pipe and a diver bolted it to the length previously laid.

The speed of this work depended very much upon the current of the river, which varied from day to day. Some days we could lay one pipe, quite often two pipes, but seldom three. At that part of the work in which we wanted a four-foot trench, we had to make it from eight to twelve feet wide at the top in order to keep it clear long enough to place one length of pipe; still, under such adverse conditions, the pipe stood the test of one hundred and forty pounds per square inch and is now well covered and shows no defects.

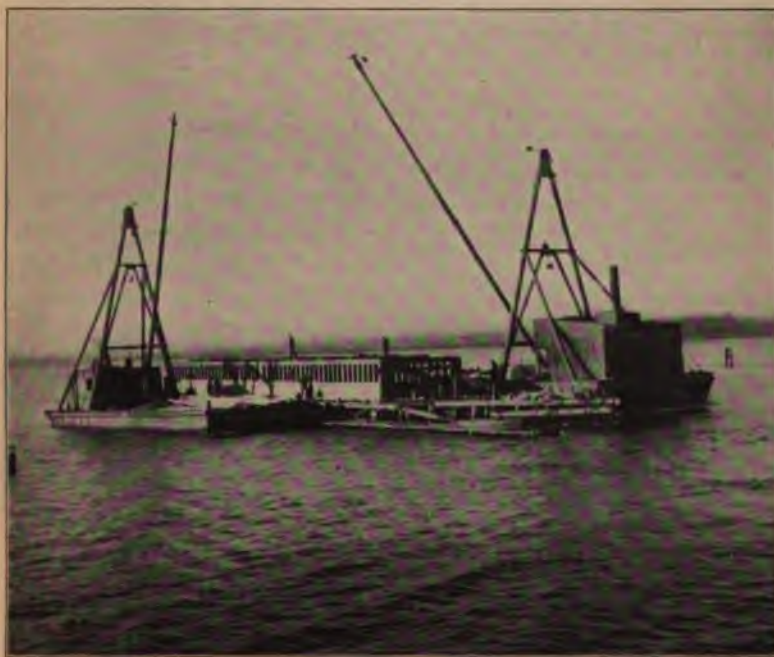
The only part of this work that was at all unusual was the loose shifting strata covering the hard bottom and the rapid current, making it impossible to prepare any length of trench ahead.

There is one matter to which I would like to call your attention:—in three abandoned pipes that I have removed, one had been down about sixteen years, another eight years and a third but one year; in all these pipes there was a larger amount of sediment than is usually found in water mains. In the ten-inch pipe, that had been down sixteen years, the diameter had been reduced to six inches. This uniform coating on the interior circumference of the pipe was so hard that a brisk pounding with hand hammer upon the outside did not entirely remove the scale, which appeared to consist of loam and rust. I know of no reason for this, other than that these pipes were at the lowest point of the system. It would appear that some provision should be made for frequent blowing off of all submerged water pipe traps. This ten-inch pipe mentioned, after being buried sixteen years in salt water mud, upon being washed, the outside was as bright as new.

THE NEW CONNECTICUT RIVER BRIDGE (N. Y., N. H. & H. R. R.), LYME, CONN.

By J. H. Soehrens.

The large increase in traffic and weight of rolling stock had made it necessary to replace by a larger and heavier structure the old single track bridge, No. 352 Shore Line Division, New York, New Haven & Hartford Railroad Company, over



PUTTING ON TOP SECTION OF CAISSON, PIER NO. 5.

the Connecticut River between the towns of Lyme and Saybrook. Accordingly, about the middle of May, 1905, under the supervision of Mr. C. M. Ingersoll, Jr., and upon his resignation, of Mr. Edward Gagel, Chief Engineer, with Mr.

R. M. Berrian as the Assistant Engineer of Construction directly in charge, work was commenced on the substructure of a new four-track bridge located about 250 ft. south of the old structure. The present intention, however, is to put into position superstructure for the two south tracks only.

The new bridge consists of nine piers and two abutments supporting seven double-track, pin-connected, through trusses 182 ft. center to center of end pins, two plate girder spans 38



LOOKING WEST FROM PIER NO. 9 DURING CONSTRUCTION.

and 70 ft. long, and a double-track, riveted, through truss Scherzer Rolling Lift Span 161 ft. long. The distance from base of rail to high water is 25 ft. and between abutments is 1,564 ft.

The west abutment is built on piles spaced 2 ft. center to center with two rows of batter piles along the front, all driven with a drop hammer. Before these were put in, and in order to reduce the thrust of the fill against the back of the abutment,

the mud flat where the abutment is located was dredged out for a distance of about 100 ft. back of the abutment to a depth of 15 ft. below low water, at which elevation fine sand was encountered. After the abutment was completed this was filled in with gravel and raised up to subgrade. The piles were sawed off 9 ft. below low water and a cofferdam was then driven around them, after which the space between the piles was filled up with crushed stone to two feet below cut-off. Con-



PIERS NO. 2 AND NO. 1 (PARTIALLY COMPLETED).

crete of a 1:2:4 mixture was then deposited under water up to 3 ft. below low water, at which point the coursed ashlar of the shaft and wings was started and carried up to high water. A large amount of heavy riprap was then placed against the back to give a lateral thrust against the abutment, and, as a dry wall, ultimately to help support the fill. Only a slight forward movement being noted, the abutment was then carried up to completion.

In building piers, No. 1, No. 2, and No. 3, all of which have the same dimensions, open caissons resting on piles were used. The river bed was dredged out to a depth of 35 ft. below high water. The material encountered below this being a very compact coarse sand, considerable difficulty was experienced in driving piles with a drop hammer and follower, so a water jet was used very successfully. The piles were sawed off 32 ft. below high water. Crushed stone was then placed between



LAYING MASONRY IN CAISSON, PIER NO. 5.

the piles and leveled off flush with their tops by a diver. The first section of the caisson, which had as a bottom a grillage 4 x 22 x 104 ft. consisting of one transverse, two diagonal and one longitudinal course, all of 12 x 12 in. yellow pine timber, and had sides 15.5 ft. above the grillage, was then brought into position, securely moored, and masonry laid therein until the sides were about 4 ft. above the water. Then another section 15.5 ft. high was added on and the masonry work resumed.

While sinking the caisson, the shaft of the pier was built hollow, strongly braced, however, by headers and crosswalls. This brought the masonry up to about 10 ft. below high water, when the caisson landed on the piles, thus enabling support to be given to the larger portion of the sides beneath the water. As soon as the caisson was landed in proper position, the hollow core was filled in with masonry and the remainder of the pier built solid.



PIERS NO. 2 AND NO. 1 AND WEST ABUTMENT (PARTIALLY COMPLETED).

The north end of each pier is built as an ice breaker, all stones therein being doweled and clamped together. Under all piers built in open caissons, 570 piles were driven in 57 rows of 10 piles each. As soon as a pier was completed it was ripraped sufficiently to protect it from all possible scour.

Piers 4 and 5 were built in the same manner as 1, 2 and 3, with the exception that the piles were cut off 39 and 43 ft., respectively, below high water, thus necessitating the addi-

tion of a third section of ten feet being added to the caisson sides. The grillage on these two piers was five feet thick. Strong triangular-shaped anchorages, well braced by batter piles and riprap, were driven just above the caissons, to which the latter were moored while being sunk. Fenders were driven around the other three sides, so that the caissons could not get far out of position.

The river bed under piers 6, 7 and 8, was bare bed rock, quite rough, 40 to 30 ft. below high water. Crushed stone was dumped in to a depth of about 10 ft., through which piles were driven by a drop hammer. They were sawed off at 28, 23 and 18 ft. below high water, and additional stone dumped in and leveled off flush with the top of the pile heads. Open caissons were then employed as before. After the masonry was completed these piers were very heavily riprapped.

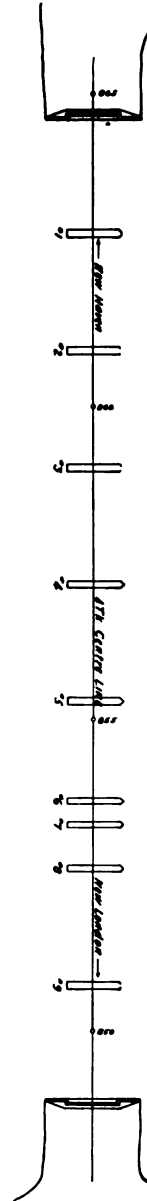
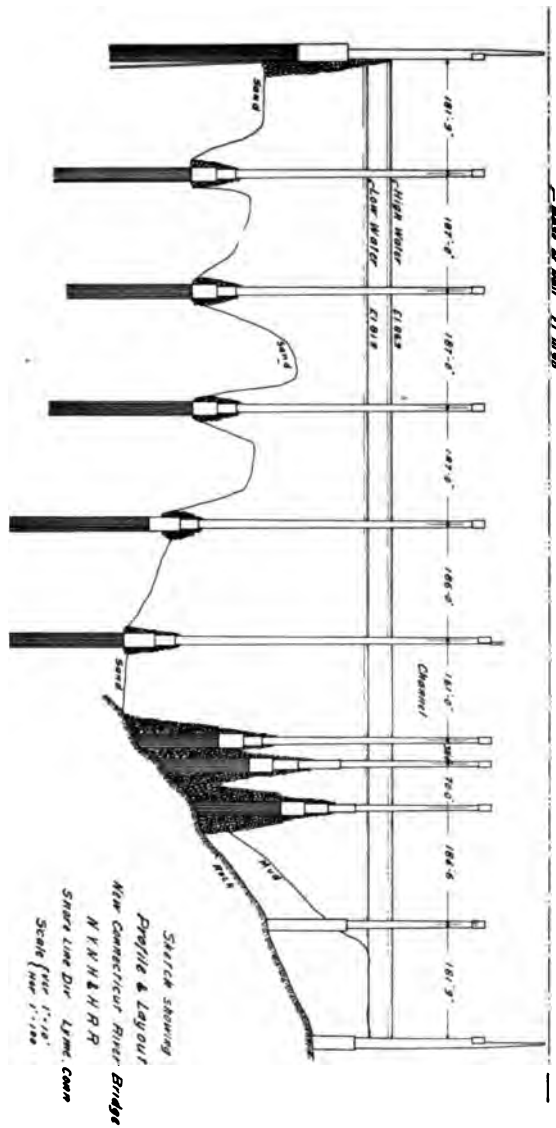
At pier 9, bed rock was encountered about 12 ft. below high water, covered by an 8 ft. layer of mud. A cofferdam was driven to rock, the mud excavated, and concrete of a 1 : 2 : 4 mixture deposited under water up to about 6 ft. below high water, at which elevation the ashlar work was started.

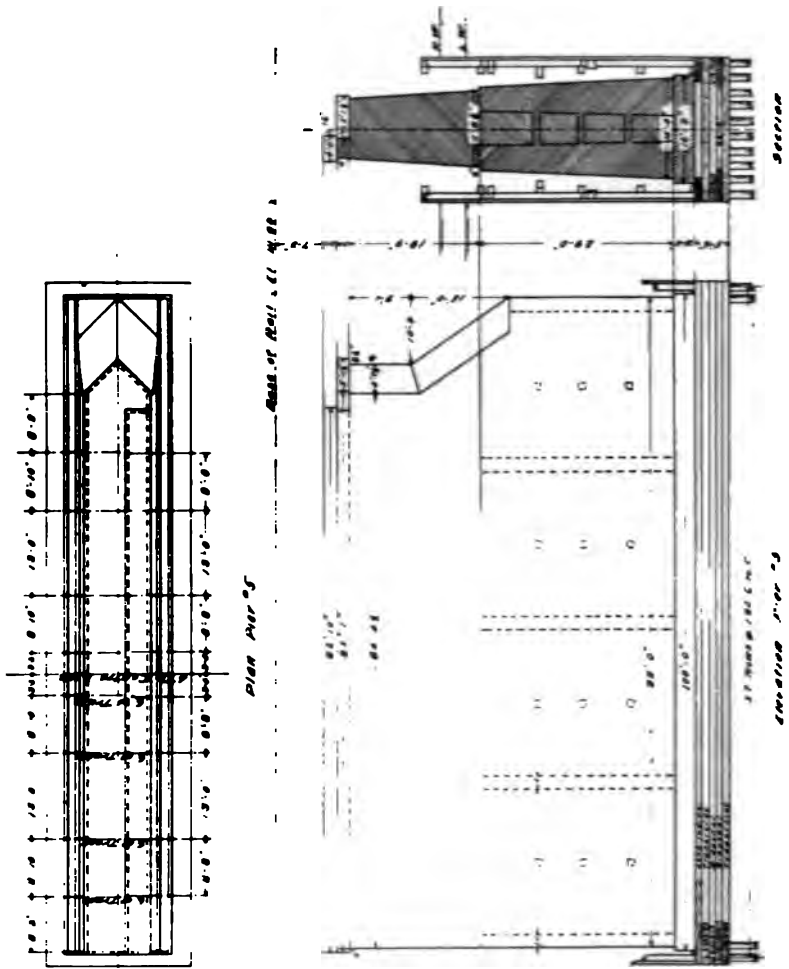
The east abutment foundation was built the same as that of pier 9, and the shaft and wings were practically the same as those of the west abutment.

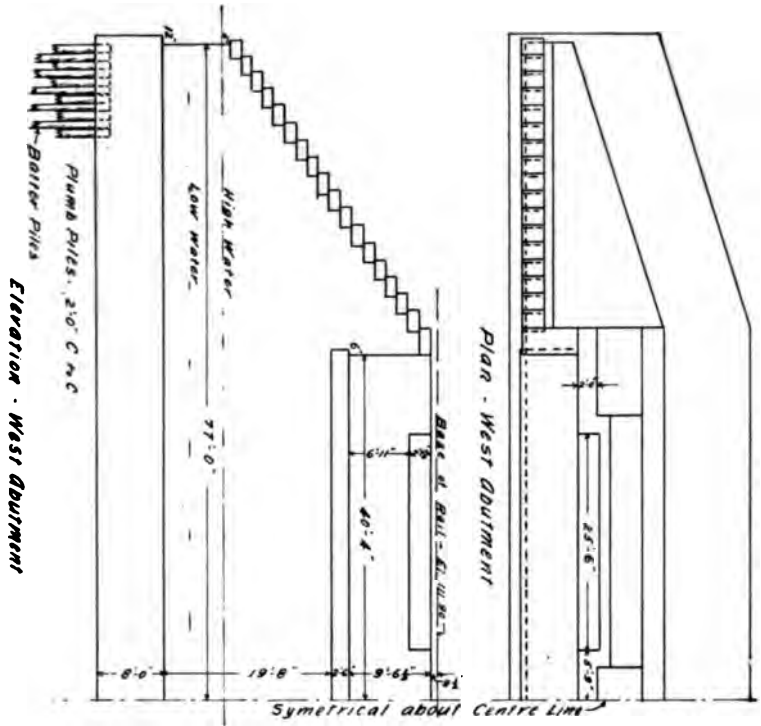
The substructure was completed in the latter part of April, 1900, four months earlier than the time called for in the contract.

During the construction Mr. R. F. Stoddard, Assistant Engineer, N. Y., N. H. & H. R. R., was the resident engineer in charge, and Mr. A. P. Law* was Superintendent for Daly & Holbrook, contractors.

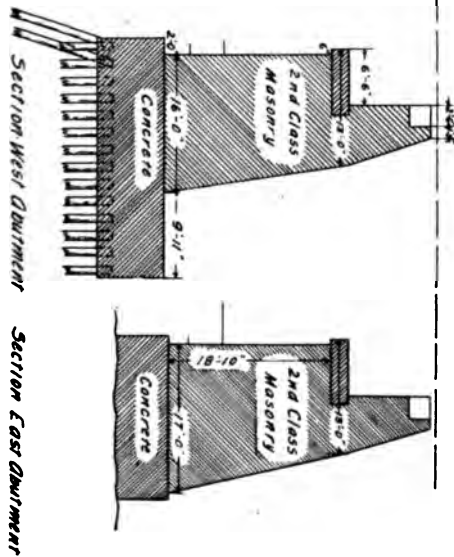
*Assoc. Mem. Am. Soc. C. E., Mem. Conn. Soc. C. E., died Nov. 10, 1900.







Sketch showing
MASONRY
ABUTMENTS & PIERS
New Connecticut River Bridge
N.Y.N.H.&H.R.R.
Shore Line Div. Lyme Conn.
Scale - 1 in. = 10 ft



sand. This was found to be impracticable on account of the difficulties experienced when it became necessary to repair the cables or to install additions to the existing plant.

The Brooks system consisted of a wrought iron pipe, along which coupling boxes were placed at frequent intervals. It was intended to make service connections from these junction boxes. An ordinary jute-covered cable was pulled into this duct, and the annular space between the cable and the duct was then filled with a resin oil. Leakage was taken care of by small reservoirs perched on stand pipes which were connected to the system at the apices of the grades. This system was used in Chicago, Philadelphia and London but was soon abandoned on account of the nuisance of clearing the ducts of the sticky compound when alterations or additions were necessary.

Another plan, invented by Col. Flad, consisted of a large pipe into which smaller pipes were placed, arranged so that proper joints could be made between them.

Early attempts were also made to build concrete subways. One of the schemes was to surround lengths of collapsible mandrels with the concrete, the idea being that the mandrels were to be removed when the concrete had set. It was also suggested that hollow concrete curbs be used on all streets and the cables installed therein.

A type of construction somewhat similar to the concrete construction referred to above, was tried out in New York except that instead of using the collapsible mandrels, zinc tubes were used. In this case the trench was first lined with creosoted boards, upon which was placed a 3 inch bed of concrete. Upon this concrete bed the zinc tubes were placed, separated from one another about 2 inches. The spaces between these tubes were then filled with concrete with another bed of concrete on top to support the second layer of tubes. This process was continued until a sufficient number of tubes had been laid.

It was found in practice that, owing to the frailty of the tubes, many of them were seriously injured by the workmen, either by walking on them, or by ramming down the concrete too vigorously, so that it was often necessary to ream out the entire subway at great expense. It was also found that the zinc tubes were very susceptible to the action of the free

chemical elements in the concrete and in the street; consequently they corroded and fell in strips into the ducts, thus clogging them and preventing the drawing in or withdrawing of cables.

Another scheme that is rather interesting historically was one used by the New York Fire Department, for carrying their fire alarm circuits. The construction consisted of a closed wooden box in which were placed, at short intervals, separating wooden partitions. These partitions had small holes bored through them and bare copper wires were drawn through the holes from one end of the box to the other. While these wires were under tension, the box was filled with a compound of paraffine and resin. It was found, however, that the wires, when the tension was removed, gradually settled in the compound, until one wire reached its neighbor, resulting in crossing out the circuits.

The Dorsett system consisted of moulded multi-tubular blocks made of a compound largely composed of coal tar and gravel. These blocks were laid on a carefully prepared bed of concrete. Compressed paper ferrules which had been treated with asphalt, and were supposed to be impervious to water, were slipped into one end of a block and the next block was then pushed up, over the ferrules, toward it, until the ends of the blocks nearly met. The space between the blocks was then filled with an asphaltic compound. The whole structure was then veneered with a brick surface set in cement. Difficulty was experienced from the softening of the paper ferrules and their misplacement, so that at times when cables were pulled in enough of the ferrules were picked up to jam the cables in the duct. Zinc ferrules were then tried but were not successful. It was also found that the system was very susceptible to heat, and consequently if it was installed where it was so exposed, the blocks softened and collapsed.

Indurated fibre was tried and signally failed. In Philadelphia it was spoken of as "Molasses Conduit," on account of the fact that it decomposed and formed a froth much like that on molasses, which ran into the manholes. This duct was largely treated with a composition which was freely acted upon by an alkali, and being surrounded by concrete, the alkali which was supplied saponified the treating compound. This soap being soluble in water, caused a froth. The manufacturing

of this type of conduit has been abandoned, but a new wood fibre conduit, differently built up and treated with an asphaltic compound, is now being produced and has been quite successfully and extensively used, particularly in the southwest.

Creosoted wood duct is largely used in many places and has been found to be very satisfactory. Cast iron and wrought iron pipes have also been used very extensively, but have been generally found to be impracticable, and now wrought iron pipe is only used where the nature of the work makes it imperative.

Cement-lined iron pipe has been, until very recently, the standard form of construction for all conduit work in Connecticut. This conduit is composed of thin strips of sheet iron about 8 feet long, riveted into the form of a cylinder and then lined with about $\frac{1}{2}$ inch of cement. The ends are provided with a special form of ball and socket joint, designed to compensate for slight inequalities in the alignment, and also to facilitate laying. While this type of duct has been reasonably satisfactory in this state, it has been found that there has been a slight action between the alkali of the concrete and the lead sheath of the cable. This gradually decomposes the cable sheath and together with other objectionable features has resulted in the abandonment of this type of construction.

Probably there is no duct material so universally popular at present as vitrified clay in some form. It has great advantages over any other type of construction that has ever been adopted. The material is cheap, of great durability, is readily handled by unskilled labor, and certainly has no injurious effect upon the cable. Still further, inasmuch as it is practically smooth on its interior surface, cables are pulled in with a minimum amount of strain.

Numerous clays and combinations of clays are used in the manufacture of this duct, even at the same factory; different samples showing upon examination varying qualities of silica, iron, and fire clay. Very little seems to be known of clay, except that it is decomposed silicious rock, and in its present state, viz., kaolin, is probably composed of alumina and silica alone. This combination when burned is very porous. Laboratory combinations according to analysis will not produce the same results as the clay analyzed, so that probably the

manner in which nature has combined the elements influences their action.

Clay suitable for this type of work must therefore be selected experimentally; those most suitable, however, contain alumina, silica, lime and iron, so that the last two may assist in the vitrification. The color is due to the presence of iron, a red clay showing the presence of a higher oxide, yellow a lower oxide, and when both iron and lime are present its color is black.

The clay should be plastic and smooth, free from limestone and pebbles, and should contain a large proportion of silica. It should be thoroughly ground, and if necessary, should be mixed with water to make it of the right consistency and is then forced through dies of the proper dimensions. These dies are designed to produce either single duct having a round bore of approximately $3\frac{3}{8}$ inches in diameter or multiple duct containing either 2, 3, 4, 6, or 9 cable-ways, and in some cases even 12 or 16. The single duct finished conduit is usually 18 inches long, the multiple duct of the smaller size, 24 inches, and of the larger sizes, 36 inches. The cable way in the multiple duct is usually $3\frac{3}{8}$ inches square with rounded corners. It is rather interesting to note that the shrinkage of this clay in burning amounts to nearly 10 per cent., so that a single duct that in the finished product is to measure 18 inches long is formed up nearly 20 inches long.

The clay tube, after being formed, is placed in a drying room, where it is allowed to remain for several days, that is until it is thoroughly seasoned. From there it is taken to the kilns. These kilns are of varying sizes, but usually contain about 20,000 feet of duct and are arranged so that the fire passes from the outside of the kiln into the inside at the top, and is drawn down by exhaust draught through and around the ducts which have been stacked up on end in the kiln. The fires are started gradually and do not reach their maximum heat for about two days, and are then kept at this point for approximately two more days, during which time the contents of the kiln are at a white heat.

At this point, before the heat is reduced, common salt is thrown on the fire to form the glaze on the ducts, which is one of the requirements of the specifications for the finished product. The fires are then gradually diminished and the

kiln is allowed to cool for approximately three days more, so that in all the duct is actually in the kiln for about a week. It is then removed and carefully inspected for any imperfections that may affect the cables that are eventually to be pulled through. The rejections on these inspections vary amazingly; some kilns have been known to run not over 6 per cent., while others run as high as 90 per cent. The principal causes for these rejections are poor vitrification, crooked duct, bore out of round, and blisters or other imperfections in the interior surface. Blisters on the exterior surface are allowed, provided they do not extend too deeply into the duct.

While the above processes apply more particularly to single ducts, the methods used for manufacturing multiple ducts are practically the same and need not be described.

Whenever the question is raised as to the proper method of taking care of underground structures, or rather the proper method of providing for underground construction of various kinds, practically all laymen appealed to and a very large proportion of engineers will, without hesitancy, state that a system of pipe galleries in which all structures underground can be placed or removed without in any way interfering with the surface of the street, is the only proper solution of the problem.

One or two cities in the United States have constructed galleries of moderate length but practically only for one class of structures. Some few cities in England are also so equipped, notably St. Helens, Nottingham, and some of the outlying districts of London. A short section has also been constructed in Milan, Italy, but probably the largest and most comprehensive system in the world is that in Paris. In 1894 over 500 miles of such galleries had been constructed and extensions were proposed for some 300 miles more, some of which have actually been built.

These Paris galleries range in size from 6 feet to about 26 feet in width, and in them are placed the sewers, which are provided for simply by an open recess at the bottom. The water pipes, some few pneumatic tubes and such of the signalling wires as are under the jurisdiction of the government, (and it may be stated that very few pipes, etc., are now owned by the municipality,) are placed in these sewers.

When the construction of these sewers was begun in 1830, it was intended to place therein all sorts of underground structures, and following out this policy, gas mains were laid with the other pipes. Notwithstanding, however, the extreme care which was exercised by the city authorities, leaks occurred resulting in explosions which were so far reaching and disastrous in their effects as to compel the authorities to exclude such structures from the sewers. This decision was not reached, however, until Paris had experimented with the gas mains for thirty-eight years.

Insulated wires of all kinds carrying large quantities of current, or current under high potential, have also been excluded, on account of the liability of the insulation to break down from various causes, such as overload, defective insulation, abrasions, etc., which usually result not only in burnouts, but also cause the possibility of igniting explosive mixtures in the gallery. There are also possibilities of arcs being formed between these wires and adjacent pipes that would seriously injure the pipes. Since these wires were excluded, practically all underground construction, except those particularly referred to as now being in the sewers, have been laid in about the same manner as in our own cities, that is, the streets have been opened when necessary and restored when the work was completed.

It should be stated, however, that all structures that are now placed underground in that city are laid beneath the sidewalks, and when cross streets are reached, tunnels are built below all existing construction without disturbing the street surface. The inconvenience to the public caused by having the sidewalks torn up is, however, infinitely greater than that which is caused by the methods adopted in this country.

Advocates of pipe galleries contend that small leaks in gas mains can at once be detected and corrected, and the possibility of installing frequent ventilators makes it possible to repair even active leaks and breaks. The detail of a few accidents that have occurred in Paris show why the authorities finally had to exclude the gas mains.

In 1864, an explosion occurred in a gallery in the Pont d'Austerlitz. The length of the gallery was 650 feet and it contained, among other pipes, a 50 centimeter gas main. The leak having been discovered, the main was stopped by inflated

bladders in the usual manner, and a workman was lowered into the subway through one of the ventilators to make repairs. The man was instantly suffocated in spite of the fact that there were six ventilators in the 650 feet of subway.

In November, 1865, in the same subway, an explosion occurred due to a leaky stop valve which killed two men and completely destroyed 520 feet of the subway and damaged the remainder so badly that it had to be entirely rebuilt. A water main 50 centimeters in diameter was fractured by the explosion and water completely flooded the subway.

On July 4, 1868, a fatal explosion occurred in the sewer of the Rue de Rivoli, in consequence of a light having been brought in contact with an accumulation of gas.

These, with many other accidents, forced the authorities to exclude gas mains from the sewers, although it is foolish to suppose that, in the thirty-eight years that had passed, every possible precautionary measure had not been adopted.

The difficulties now being experienced in ventilating the Rapid Transit Subway in New York are an indication of troubles which must occur in any construction of this kind.

The result has been that competent engineers who have carefully studied this subject each exclude certain structures, until there seems to be but little left except small water mains and cables used for signalling purposes; and in fact in the latest plans it has been proposed to take care of even the signal wires in the walls in a separate conduit composed of individual ducts 3 inches in diameter.

As stated in the early part of this paper, practically all the standard methods of construction for telephone subways now call for vitrified clay duct of either the single or multiple types. Obviously, the multiple duct is cheaper to lay per duct foot, than the single duct. On the other hand, the multiple duct is not as flexible, is more difficult to handle and transport, and is much more subject to losses from breakage. Therefore in the completed structures, duct foot for duct foot, there is very little difference in cost between the two, and the type of duct that shall be used is largely a matter of judgment in each particular case. It can readily be seen that multiple duct on account of the greater length of the sections, and on account of the increased cross-section diameter of the material, is not as

flexible as the single duct, and where obstructions are apt to be met with, as in city streets, the single duct is usually more satisfactory.

After the necessary permits are obtained for underground construction, from the city authorities, the city engineer is consulted and a definite location in the street for the conduit is decided upon, as clear from other structures as is possible. It is sometimes necessary before this location can be definitely decided upon to dig test holes at such intervals as may be necessary to locate possible obstructions. It is preferable, of course, to have the conduit reasonably near the curb line on account of not interfering with traffic, but it should not be near enough to cause trouble from surface drainage.

The trench is excavated of sufficient width to properly accommodate the number of ducts that are to be laid, but at least three inches must be allowed between the sides of the trench and the duct. The depth of the trench is of course dependent upon the local conditions, but must always be sufficient to allow for at least two feet of earth or paving above the finished duct section. If possible, the conduit should always pass beneath gas service pipes or similar structures. It should also always be laid to grade so as to drain into the manholes at the ends of each section. Obstructions met with in the trench should be properly protected until the work is completed, or, if necessary, moved to some new location that is satisfactory to all parties concerned. The trench must be kept free from surface water and if possible any springs met with must be drained.

After the trench is completed and the bottom properly smoothed off to grade, a bed is laid of from 3 inches to 6 inches of well rammed concrete, composed of Portland cement, $3\frac{1}{4}$ inch stone and sand mixed in the proportions of 1, 4 and 8. This extends 3 inches on each side of the duct section. It is sometimes necessary in unstable ground to reinforce the bed with twisted steel wires laid longitudinally. The concrete is then allowed to set, if possible, and is next covered with a thin layer of mortar on which the initial layer of ducts is placed, in single duct construction, care being taken to break the joints of the ducts and to have the vertical space between them as narrow as possible. The space between the ducts is flushed to

the upper surface of the ducts with mortar. Another layer of mortar is then placed upon this tier of ducts to insure an even-bearing surface for the next tier of ducts, and they are then laid in the same manner as the first tier, care being taken to break the joints not only between this layer, but also between this layer and the preceding one. This process is continued until sufficient ducts are installed. As the ducts are laid, mandrels are drawn through them equipped with a heavy leather or rubber washer, so as to remove all loose mortar that may have fallen into them.

When sufficient ducts are laid, they are surrounded on both the top and sides with 3 inches of concrete of the same mixture as the bed. The trench is then properly filled in and thoroughly tamped, care being taken not to disturb the ducts. The filling should then be allowed to settle before the permanent pavement is replaced.

Multiple duct is laid in practically the same manner as single duct, except that alignment of ducts is insured by using dowel pins between each section, and the joints themselves are protected by strips of muslin about 8 inches wide, thoroughly soaked in neat Portland cement.

It is usually considered good practice to lay a creosoted plank on top of the concrete to protect the completed structure from mechanical injury.

In some cases it is possible to do away with the concrete on the sides, sometimes on the top and it has even been suggested that the concrete bed in suburban work can be eliminated provided the earth is sufficiently stable, these modifications of course being designed to allow of a cheaper form of construction.

Where the trench passes through rock, and blasting is necessary to open it, it has been found advisable to install sections of creosoted wood duct on account of the fact that in case other trenches are opened adjacent to the conduit, the blasting for them often shatters the clay duct and causes serious damage.

Manholes are of either the two, three or four way types according to the requirements at each particular point, and should be located at street intersections, but if back yard distribution is to be used, it may be advisable to place them near the middle of the blocks, never, however, over 500 feet apart.

They should be designed to be as roomy as possible and space should be allowed for the necessary splices in the cables which pass through them. They may be built of either brick or concrete, are usually oval in shape and for ordinary cable runs vary from 5 feet 6 inches to 6 feet 6 inches long, from 3 feet 6 inches to 5 feet 3 inches wide, and are about 5 feet deep in the clear. They should be so located as to avoid any pipes or other structures passing through them when finished.

Manholes should be drained, and it is usually advisable to build them with concrete floors. In concrete manholes concrete tops are often used, but on account of the time taken for the concrete to set before street traffic can be resumed, tops constructed of 60 lb. rails filled in with brick are usually preferable, and in fact it has been found in Connecticut, that manholes entirely of brick are usually more practical. The covers are usually of cast iron but sometimes are of steel, and are generally single although in some cities double covers are required.

It is sometimes necessary to employ wrought iron pipe in main conduit runs as at bridge crossings, or where similar conditions exist, but its use is to be avoided whenever possible. Laterals to poles and to buildings are, however, usually of this material.

There is a tendency towards the consolidation in one trench of conduit for light, power, telegraph and telephone purposes, on account of the apparent saving in expense of construction. As a general proposition, this practice should be avoided, however, on account of the liability of burnouts from the power or light currents. A serious accident of this nature occurred in St. Louis in June 17, 1904, and it is reported that not only were the telephone cables damaged, but that the ducts themselves were destroyed and had to be replaced.

Mr. Charles W. Steinmetz in a paper entitled "High Power Stages in Electric Distribution Systems of Great Magnitude," read at the proceedings of the American Institute of Electrical Engineers on May 10, 1905, describes a serious accident that occurred at New York on May 23, 1903. There have been several other serious accidents, particularly in Fifth Avenue between 42nd and 43rd Streets. Mr. A. Buck, of the Niagara Falls Power Co., has a paper presented before the American Institute of Electrical Engineers on May 10, 1905, entitled

"Duplication of Electrical Apparatus to Secure Reliability of Service," states specifically that wherever possible duplicate conduits should be constructed on opposite sides of the streets. While he referred particularly to duplicate conduits for power plants, his statements apply with equal or greater force to the consolidation of power and telephone conduits. Wherever conditions of this kind cannot be avoided in any possible way, the telephone and power ducts should in any case be separated by a wall of concrete at least 6 inches in thickness.

In several cities in Connecticut a system of direct underground distribution has been installed designed to enable service wires to be connected with the main cables in the manholes, in this way avoiding all necessity of overhead wires. Unfortunately this system has not been an unqualified success, as no methods have been found for satisfactorily joining the service wires to the cables.

Then too, the rapid development of the residential districts, from a telephone standpoint, has resulted in serious congestion in the service ducts and the maintenance on the system as a whole has not only been excessive in cost, but the plan, on account of difficulties experienced in replacing defective service wires, has often resulted in serious interruptions to the service. It is now generally conceded that the only condition where underground distribution is practical is for buildings where there are enough subscribers to warrant the installation of a small service cable, similar in construction to the main cables in the street, so that it can be spliced directly into the main cable in the manhole.

In residential districts, where the stations are more or less scattered, back yard lines are, for all parties interested, probably the most satisfactory way of giving service. Each of these back yard lines can be fed by means of an underground lateral pipe which contains a cable of sufficient size to serve all the stations in the block. The great advantage of this system is at once apparent when it is realized that it does away with all aerial service wires in the streets.

Now that the subway from New York to New Haven is completed and the possibility of continuing it to Hartford in the near future is being considered, it appears that a complete subway from New York to Boston is only a question of a few

years, and the question naturally arises as to what will become of the aerial lines which now cross this state in every direction: for the public generally, and naturally, supposes that the only reason underground conduit is not built for these circuits is on account of the great cost of the work.

Theoretically and practically, in the present stage of telephone engineering, it would be impossible to carry on a conversation between New York and Boston, through any cable that has ever been designed. Commercial transmission is limited to the transmission that would be obtained with standard instruments, connected together through a No. 10 B. & S. gauge paper insulated low capacity lead encased cable 30 miles in length. This would be equal to the transmission over about 850 miles of No. 8 B. W. G. copper wire (.165 inch in diameter) strung on poles with no cable in the circuit, or over about 200 miles of No. 12 N. B. S. copper wire (.104 inch in diameter), under the same conditions. It should be noted that this includes the entire circuit between the two stations that are using the circuit, and that therefore the transmission is not only dependent upon the length of the toll line, but is also dependent upon the distance the subscribers are from the point where they are connected to each end of it.

Under practical working conditions, the 30-mile limit is sometimes exceeded, but the results are not usually satisfactory. The problem therefore that confronts the telephone engineer is, what methods can be employed to bring two instruments which are "speaking" within 30 miles of one another.

In 1890, Dr. Michael P. Pagen discovered a practical method of applying Dr. Heaviside's theory, which was "that inductance in a telephone circuit is of advantage if it can be uniformly distributed." The practical application of this principle, broadly speaking, consists in inserting inductance coils in the telephone circuit which counteract the effect of the capacity in the same circuit. By means of these coils, the efficiency of telephone cables has been greatly increased, so that it is now possible, by the use of loading coils, to gauge cable about 40 miles long, to get the same transmission over it as over an unloaded No. 10 gauge cable 20 miles long. In other words, an increase of efficiency of 100 per cent.

The use of larger conductors in the cable has also enabled us to increase this distance quite materially, but in the present state of the art, it would be impracticable to use conductors of large enough size to make it possible to transmit commercial messages through cables for more than 150 miles. This of course prohibits the use of through cable circuits between New York and Boston.

Another recent device, which is now being experimented with, and with considerable success for long aerial lines, is the telephone repeater. The New York-Chicago circuits are now equipped with these repeaters, and since they were adopted, a marked improvement in transmission has been noted. The repeater, however, is not, in its present state, applicable to cable circuits, nor to any aerial circuits except those of great length, so that at present there seems to be no immediate prospect of its general adoption.

It will therefore be readily seen that in the present state of the telephone art, cable circuits can only be used for what might be called short haul business, and that the aerial lines will have to be maintained for all long haul or through business. Taking the short haul business with the cable circuits, of course, takes a great load off the aerial lines, and in this way we can use them to much better advantage than we could when both long haul and short haul business was passed over the same wires, more or less indiscriminately.

We of course would all like to look forward to the time when all main lines would be in underground conduit, but at present there are no reasons for supposing that it will ever be possible to abandon entirely the present forms of aerial construction.



TOWING LUMBER THROUGH CHESAPEAKE AND DELAWARE CANAL. RAFT, 600
FEET LONG.

EPOCHS OF TRANSPORTATION.

By Lewis M. Haupt, C.E., Sc.D.

Mr. President and Members of the Connecticut Society of Civil Engineers:

In accepting the honor of addressing this Society, it appeared to be appropriate to submit a few thoughts relating to the congested conditions affecting the traffic of the country at this time, and the possible avenues of relief. For this purpose it is necessary to pay attention to the physical routes of the world, the history of their development and the relative growth of population, mileage, tonnage, terminals, and many other elements affecting the question.

One of the fundamental factors is the increase of population in the United States, which has grown faster than any other country, as will appear from a comparison of the census tables of the world.

Within thirty years our numerical strength will have doubled, while the railroads are not able to meet present demands for transportation, and a large part of the crop of last year is unharvested while our citizens in the Northwest are suffering for lack of fuel and food. The mileage of the railroads is not increasing as fast as the population, yet the tonnage offered is growing five times faster.

The waterways, which were built by corporations under State charters prior to the Civil War, increased rapidly, and there were 5,000 miles in operation at that date, which had cost about \$150,000,000, but since then nearly half of this mileage has been acquired by competing lines of railways and put out of service. Now, there is a growing desire for these cheap servants of the public, and the railroads themselves would do well to rehabilitate them and carry the low grade freights by water at less cost and greater profits, as will appear later in this paper.

The drift of legislation has been toward a centralization of authority and control by the general government, which has

tended strongly to arrest State and corporate initiative and restrict the improvement of the canals, under the popular impression that tolls should not be charged. But all other lines of transportation under improved management are authorized to collect fares or tolls and cannot exist without such sources of revenue. The same necessity must be accorded to the water-routes or they cannot exist, for the government is not able to provide for the demands of the entire country. The most important of our public civil works have originated under the corporate system, with revenues from tolls, and there appears to be no early relief in sight without a restoration of that method of encouraging these great economic factors, the waterways, under private initiative. It is the function and duty of the engineer to project, construct and operate these important conservators of the domestic commerce of the country. It is our heritage, but we need first to remove the shackles and secure enabling legislation.

"The Back-Sight."

The full import of this statement will be appreciated better by a brief review of the conditions which have attended the effort to regulate commerce between the several states and with foreign nations.

INTERNAL IMPROVEMENTS.

Roads.

In the evolution of internal improvements the first step was taken in the bettering of the highways, and as it cost \$125 to haul a ton of freight across the Alleghanies from Philadelphia to Pittsburg, (or at the rate of about 35 cents per ton-mile), the people were not slow to respond to the opportunity to mend their ways, and the first turnpike in the United States was built, from Philadelphia to Lancaster, 62 miles long, between 1792-1794, at a cost of \$405,000, by a private company, operating under a state charter.

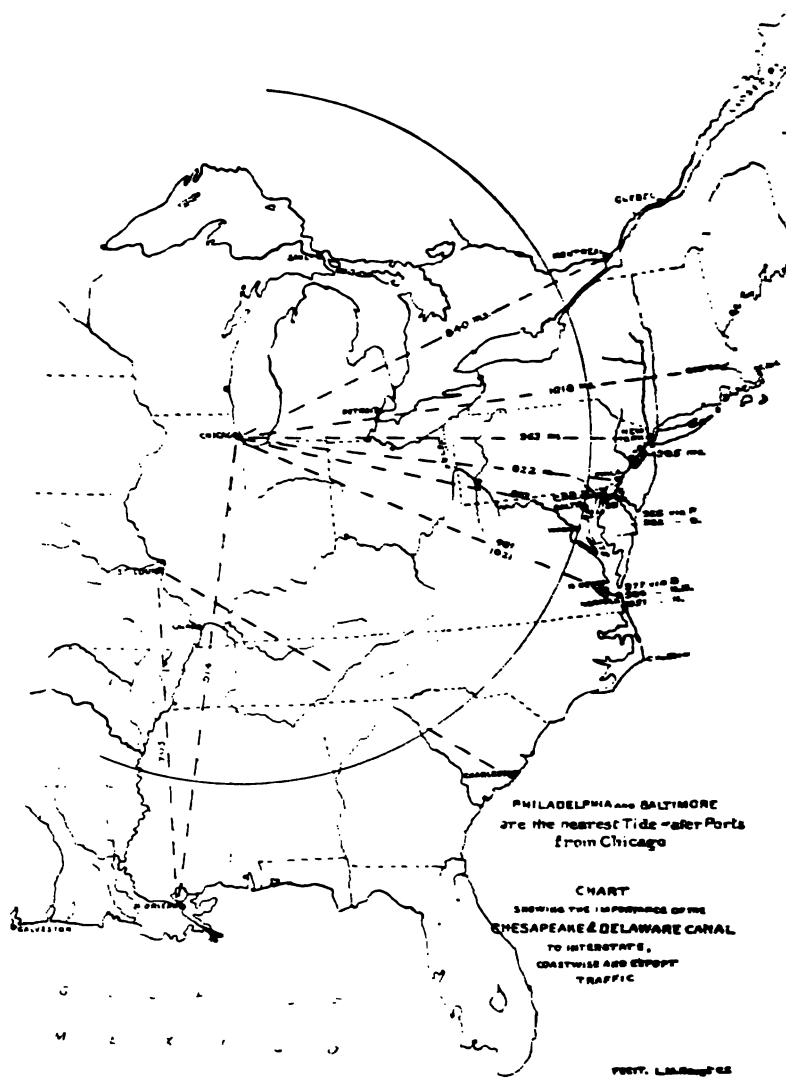
The Nation, as such, gave very little attention to the development of ways of communication, but left them almost exclusively to the states and corporations under them. Thus Pennsylvania began at an early date the work of road improvement, and between 1792 and 1822 had chartered some 220 turnpike

companies, which built about 1,788 miles at a total cost of nearly \$6,000,000, of which 30.4 per cent. was subscribed by the state and the balance by private parties. This includes the 80 miles of the Cumberland Pike or National Road to the Ohio, which passes through Pennsylvania, and for which the funds were applied from the sale of public lands in Ohio. The average cost per mile was \$3,280.

So great was the demand for transportation, that many of the states followed the example of Pennsylvania, and by liberal charters and grants of tolls, encouraged the people to make roads for themselves. The wisdom of this policy soon became apparent. The rage for turnpiking rapidly spread over the whole country, and in a few years a sum almost equal to the national debt at the close of the Revolution was voluntarily invested in the stock of these corporations. By 1811 New York had chartered 137 companies with a capital of over \$7,500,000 and a total mileage of 4,500 miles, of which more than one-third was constructed. Yet the cost of transportation was enormous, and in many cases prohibitory, so that attention was soon diverted to the superior advantages of the waterways, and the canal epoch was inaugurated simultaneously with that of the roads.

Canal Development.

There is not time to review the history of this movement, but suffice it to say that as early as 1690, William Penn contemplated the project of uniting the Susquehanna and Schuylkill rivers by a canal, through the province, and the first explorations for this purpose were made by a Committee of the American Philosophical Society in 1770. A survey followed under David Rittenhouse and William Smith, Provost of the University of Pennsylvania. In 1773 John Bellendine of Virginia published his project for connecting the Monongahela with the Potomac and the Kanawha with the James rivers. In 1785 Washington was elected president of the Potomac Company, chartered to connect the Ohio River with Chesapeake Bay. On January 5, 1786, the James River Company was incorporated and the following year the Dismal Swamp Company was authorized to connect Albemarle Sound with the Bay of Chesapeake. The first canal, however, actually opened was that



THE CHESAPEAKE AND DELAWARE CANAL IS THE "LINE OF LEAST RESISTANCE"
OF THE CHEAPEST STANDARD FOR ALL RAIL SHIPMENTS FROM CHICAGO.

built at South Hadley in Massachusetts in 1792, which was followed by the Santee Canal of South Carolina, begun in 1793 and finished in 1800. The Chesapeake and Delaware Canal was chartered in 1797, and a large sum was subscribed to start the work, but it was insufficient, so that in 1805 an appeal was made to Congress for aid, which was granted after a long delay and the work was opened October 17, 1829. The government also subscribed to the shares of the Louisville and Portland Canal, opened December 22, 1830, and of the shares of the Dismal Swamp Canal it subscribed for 800 @ \$250, or \$200,000—up to 1839.

In general, however, the government exercised no control over the works which were constructed and operated by corporations under state charters, and it was slow to aid these works by subscriptions, yet under this policy the canal systems expanded so rapidly that up to the time of the Civil War there were in use as stated 5,000 miles of improved waterways, involving an expenditure of state and private funds amounting to over \$150,000,000, as compared with less than \$15,000,000 from the national treasury applied to similar purposes. Since that date the policy of the government has radically changed, and although over \$550,000,000 have been appropriated to river and harbor improvements, the actual mileage of our internal canals and improved rivers has fallen to about one-half that of 1860.

Railroads.

This is in part due to the introduction of the railway and the use of steam as a motor, beginning in 1826, at Quincy, Mass. In the four-score years which have passed the mileage has increased to over 220,000 and the value of the properties to more than \$16,200,000, so that it has grown to be the dominant industry of the country. To secure the greatest possible efficiency and economy, it became necessary gradually to eliminate the short disconnected links in the chains of communication between our great cities and the seaboard and to wipe out the competitive waterways, so that the railroads have by this process of absorption, elimination and concentration become so potent as to excite grave fears as to the outcome, and serious efforts are making to regulate their rates by further legislation.

Rail Rate Regulation.

But it must be evident that the rates charged on transportation must depend upon local conditions, physical obstacles, character of service, length of haul, and many other factors which general legislation cannot cover, and that any attempt to do so would be disastrous to many roads as well as to their patrons. The enormous sum invested in transportation is a measure of the confidence of the public in corporate management, even though the returns are relatively small, being but a little more than 3 per cent. It is also more than probable that if this great business is to be managed by legislation, the officers of these roads must manage and control legislation, even to a greater extent than at present, and there would result a railroad oligarchy.

In a Memorial to the Legislature of Pennsylvania, the President of the Reading Railroad pertinently remarks;—"There is no necessity for government regulation, other than to prevent unreasonable discrimination. Government regulation, because it must be fixed by rigid rules, can harass and annoy, but it cannot beneficially assist the varying demands of business."

The best regulators of rates are physical laws, properly applied, and when railroad managers begin to appreciate the great benefits to them, as well as to their patrons, from the utilization of the cheapest means available for the delivery of their tonnage and the segregation of the crude raw materials, as fuel, lumber, iron and other ores from the high class freights, they will need no additional legislation except that which may be required to prevent discriminations and too great centralization of power. There are inherent differences between the railway and any other mode of communication, arising from the fact that the railroad company owns and operates the *track or way*, which is not open to the public, as is the highway, the river or the canal. On these latter ways, while there may be tolls, there is no definite schedule, and anyone may use the roadway at his convenience, by day or night. To restrict this public privilege in any way is injurious to the public weal, and to usurp or secure the control of these natural or artificial avenues of trade in such manner as to retard their development by localities desirous of securing relief or greater accessibility to the markets, is unwise, if not ruinous.

A brief reference to the average rates charged by the railroads of the United States in the several geographical districts will serve to show at once the influence of physical conditions on rates.

Thus in Group I, comprising the New England States, where there is not sufficient food nor fuel to supply local demands, and the waterways are not used to any great extent for transportation, the average railroad rates are 1.167 cents per ton-mile and the revenue per mile of railway is \$7.681. In Group II, extending from New York to Maryland, inclusive, the rate is but little more than half the above or 0.667 cents and the revenues per mile are almost double or \$14.010. For Group III, along the upper lakes and subject to the cheapest water competition in the country, the ton-mile rate is still lower, viz., 0.607 cents and the receipts are \$8.833 per mile. This district embraces the States of Ohio, Indiana and Michigan, which are not connected with the seaboard. From Virginia to South Carolina the rate is 0.691; from Kentucky to the Gulf it is 0.839; from Illinois to North Dakota, 0.766; from Nebraska to Montana, 0.900; from Arkansas to Colorado it is 0.988; for Louisiana and Texas it is 1.096; and for the Pacific Coast Group it is 1.098 cents. To fix upon a maximum of say one cent per ton-mile would therefore drive the New England roads into bankruptcy and the citizens from their homes and prevent their disposing of their farms or factories to any successors, and cause a return towards barbarism. If, on the contrary, the cheaper natural avenues of transportation be authorized to be developed by local initiative, wherever it may be desired as a commercial enterprise, the results would be beneficial to all interests.

Waterways as Regulators.

The influence of the water routes in regulating rail tariffs may be illustrated by a brief reference to the rates existing between New York and a few southern points on the coast and in the interior. From New York to Wilmington, N. C., the rail rate per ton-mile is 1.3 cents; to Charleston, S. C., 1.2; to Savannah it is 0.9; to Jacksonville and Pensacola, Fla., 0.86, and to Mobile, Ala., 0.8 cents, showing a decreasing rate as the distance increases. All of these seaport rates are higher than the average rail tariff for the whole country, so that there is a

margin of profit notwithstanding the competition with the ocean steamers. On the other hand, for interior points, such as Rutherfordton, N. C., the tariff is 1.9 cents, for Athens, Ga., it is 1.7, for Birmingham, Ala., 1.5, and for Jackson, Miss., 1.2 cents, so that the overland rate to non-competitive points is about 75 per cent. higher than to the seaports. Moreover, the depth of water in the river channels also affects the rail rates, which drop off as the stage of water rises or when the channels are not closed by ice. The difference in price between high and low water rates on the Mississippi river would make a profit to the Nebraska farmer of \$1.30 per acre on wheat and amount to about \$10,000,000 to the State if carried to New Orleans, instead of overland to New York. This will explain a remark once made by a prominent railroad president concerning the building of the levees along the Mississippi for the improvement of the navigation. He said:

"The outlet system is correct and the only way to deepen the Mississippi river. If that were done what would become of not only my own, but all the other railroads coming to New York? They would be ruined, and for that reason we would favor the levee system, for so long as that be kept up there need be no fear of the Mississippi as a competitor."

Appropos of this statement, it may be well to note that in a late report of the Commission, and after about \$100,000,000 have been expended on the river to deepen the channel, it is said that "Experiments are continually being made looking to the best use of available material and the development of appliances and methods which may be economically and effectively employed when Congress shall provide for such systematic improvement."

No National Relief in Sight.

And this statement calls attention to one of the most serious obstacles in the opening of our watercourses, namely the difficulties of securing legislation from the National government when all the sections of the country are importuning Congress for appropriations, which are so restricted, and when the bill may be so readily defeated, that it is only passed with the greatest difficulty every second or third year. The important public works which are awaiting appropriations to-day are

estimated to require some \$500,000,000 and for this reason no new projects can be considered for years, and rigid rules are adopted to restrict the proper and natural development of these rate-regulators. Some of the states are, however, proceeding to enlarge their systems within their borders, as New York, Illinois, Massachusetts, and others, by making large appropriations for waterways. The necessity for this is clearly shown by the experiences of the past, for many of the most deserving works have been waiting for many years for the mere permission from Congress to construct or enlarge their facilities more rapidly.

Delay in National Action.

In 1811 the government refused the petition of New York to aid in the work of the Erie Canal; in 1835 it declined the request of Michigan to assist in the great work at the Sault, on the ground that it would pass through an Indian reservation. It was built by state aid and opened in 1855 and afterwards purchased by the government in 1881. In 1852 the state of Pennsylvania authorized the Pennsylvania Railroad Company to engage in the improvement of the Ohio river, but the government did not sanction it and for over seventy years this work has been under way, with at least fifty more in sight, before the project may be completed for a nine-foot stage. The attempt to secure a national charter for a canal between the Ohio river and Lake Erie, without aid from or charge upon the government, was ten years in Congress. The effort to secure the freedom from tolls of the Chesapeake and Delaware Canal and its enlargement for coastwise commerce and defense, has been before Congress for thirty-six years and seems to be far from a solution. The present limited coastwise canals were all built by private parties prior to 1829, and the importunate petitions for their emancipation remain unanswered. The Harlem channel between the Sound and the North River has been before the country for almost a century and is not yet completed. These and many other instances may serve to point out the great need of some remedial legislation authorizing a return to the ante-bellum policy of local initiative under state jurisdiction, that our surplus products and manufactures may be handled expeditiously; for the tonnage has far outgrown

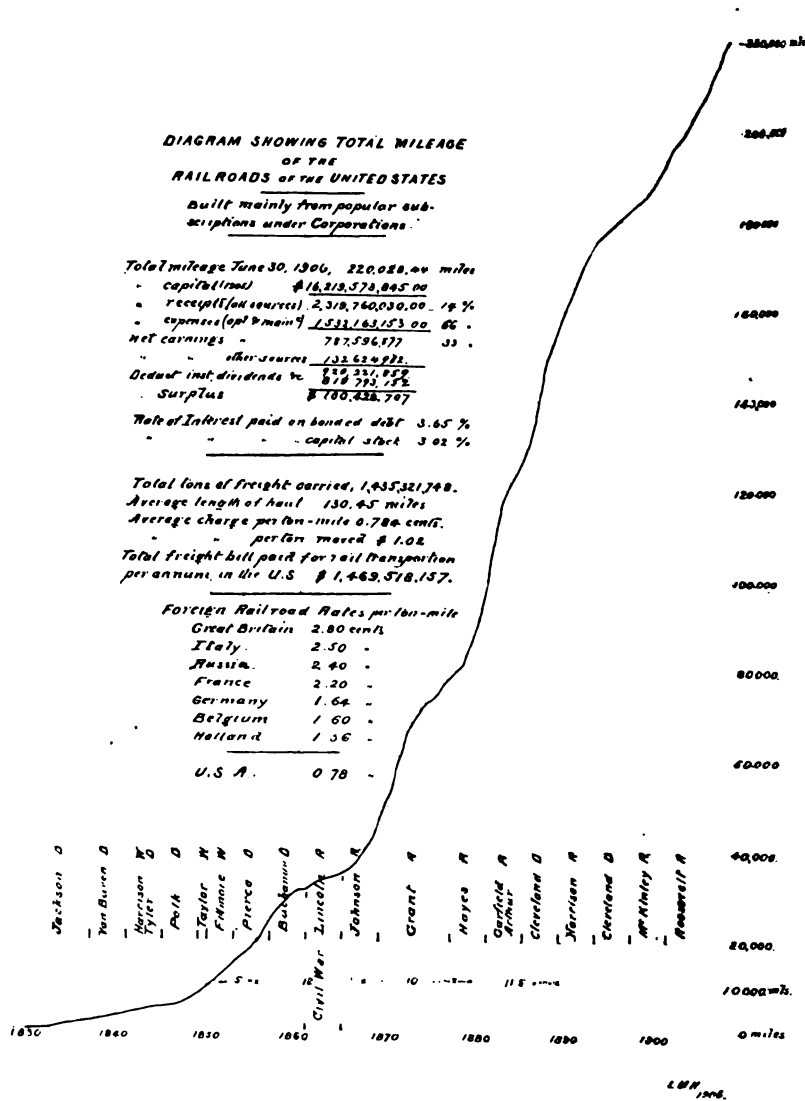


DIAGRAM OF INCREASE IN THE RAILROAD MILEAGE OF THE UNITED STATES
WITH STATISTICS FOR 1905 SHOWING FOREIGN RATES WITH WATER
COMPETITORS.

the ability of the railroads to handle it, and some of the most sagacious of their managers are demanding relief by artificial waterways down the Great Valley to the Gulf.

Traffic Engorgement.

The critical condition which confronts the country will appear from a glance at the curve of progress of the population, the mileage of the railroads and the tonnage, from which it is seen that while the population has been increasing at the rate of 22 per cent. in the last decade, the rail mileage increased only 18 per cent., while the actual tonnage increased 73 per cent. in the same time. In 1890 it was 636 million tons, while in 1905 it was 1,435 million tons. The capacity of the cars has been increased about two and one half times and the number of units also, but the impossibility of handling at the terminals prevents their use on the road more than two hours out of twenty-four, according to Mr. Hill, which is but 8 per cent. of the time, so that the efficiency is actually diminished and there seems to be no prospect of relief from this source. Radical changes in the relation of the several systems of transportation are necessary, that the waterway may again be fully and freely developed under local initiative and control.

Economics.

It is an indisputable physical fact that the waterway possesses far greater advantages for economic transportation than any other medium, so great in fact that the cost of movement is from about one-third to one-twentieth less than by rail, thus making it possible to save from 66 to 95 per cent. of the charge and correspondingly extending the market range of the commodities. It has been the policy of many of the overland carriers to lease or purchase the canals, which were first constructed, and to divert their traffic to the railway at greater cost to the consumer, who must ultimately pay for the wear and tear. The Erie Canal being a public improvement, free of tolls, has been subject to several bitter struggles for existence, but the wisdom of the citizens of the Empire State has been equal to the emergency and they have determined by a large vote to expend \$101,000,000 in increasing the capacity of that trunk line by giving it a depth of 14 feet and thus assisting to retain the commercial prosperity, not only of their own state

but of the eastern seaboard as well. It is now contemplated to extend these benefits to New England by the construction of a ship-canal across the Cape Cod peninsula by way of Brockton, Taunton and Fall River, which should commend itself to every patriotic American.

Extermination Abroad.

The partial extermination of the canals of Great Britain furnishes a timely warning; for the development of the railways



HAULING RAILROAD TIES THROUGH THE CHESAPEAKE AND DELAWARE CANAL.

in that country became so potent that, "in 1845 Parliament expressly sanctioned the control of canals by railway companies, whether by amalgamation, lease, purchase or guarantee, and a considerable amount of canal mileage came into the possession, or under the control, of railway companies. But it was discovered that this act was injurious to public policy, and in consequence, this sanction was practically repealed by the Railway and Traffic acts of 1873 and 1888. By that time about one-third of the canals had been acquired by the railway companies.

In this country the wreckage has been much greater. In Pennsylvania, for example, there were reported to be over 1,000 miles of canals in existence in 1870 and in 1889 the census returns showed only 217 miles in operation, while at the present day it is officially stated that "the canal of Pennsylvania is a reminiscence. It is not easy to discover the bed of the old canal. The levelling process is rapidly filling its trenches and the young growth of timber in some places has so obscured its location as to prevent it from being easily discovered."



THE ERICSSON STEAMER, LORD BALTIMORE, EN ROUTE PHILADELPHIA TO BALTIMORE, IN THE CANAL.

"For the last ten years the amount of shipment upon the canals has been comparatively insignificant." "The average receipts per ton per mile upon all the railroads are very much lower than they were when the canals of Pennsylvania were in operation."

Under this statement of fact it is surprising that the railroads do not restore the canals, to increase their revenue, for this reduction is undoubtedly due to the fact that they must carry crude, raw material at lower rates to maintain the indus-

tries of the state, which the canal formerly relieved them from and still delivered at a profitable lower rate to the manufacturers. Foreign railway statistics confirm this conclusion.

"At the time of the sale of the public works, many years ago, it was in the contract of the sale that the canals should be kept open by the purchasers for the convenience of the people in the transportation of their productions."

Is it not high time to inquire why this stipulation has not been fulfilled or to proceed to recover the property for the violation of this vital condition?

The injury does not stop here; the national link across New Jersey, connecting the waters of the Delaware with those of Long Island Sound and the Hudson river, was leased by a railroad corporation in June, 1871, for a period of 999 years with an annual guaranty of ten per cent. interest. This Delaware and Raritan Canal, with only seven feet draught, was transporting in 1866 about 4,000,000 tons of freight and earned that year a net revenue of \$933,642, on a capital of \$4,381,251 or about 23 per cent., while its operating expenses were less than one-tenth of those of the parallel railroad. The condition of the canal to-day is that the traffic has been reduced, by the operating company, to about one-tenth; the cost of operation exceeds the revenue by \$114,444, and in addition there is the ten per cent. interest to pay, making a deficit of over \$600,000, which must be made up by the charges on the traffic carried by rail, and which is paid by the public for the privilege of thus restraining interstate commerce. The government does not appear to favor action upon the numerous appeals to restore and enlarge these important waterways, and has done nothing since their creation in the early part of the past century, for the improvement of these vital channels of coastwise commerce and defense.

But the railroads are now engorged and crying for relief from the excess of tonnage, by the restoration of their so-called old time "competitors." This cannot be secured under national appropriations because of the enormous amount of work already under way, and for which about \$500,000,000 are required to complete. State and private capital must come to the rescue and tolls must be charged, as is still done for transportation on railroads, but "*the way*" will be open for all classes of boats and the engorgement will be greatly relieved for the general good.

The concentration of enormous wealth or patronage in the hands of one or more individuals, whether for political or personal ends, is a menace to the welfare of the Republic. No



OYSTER BOATS FROM CHESAPEAKE BAY PASSING THE ST. GEORGE'S LOCK,
CHESAPEAKE AND DELAWARE CANAL (220'x24'x10').

public property is safe when the control of its securities is "on 'Change" and may pass into the hands of a more powerful rival at any time, and but few corporations can afford to retain the majority of their own securities for self protection.

No corporation should be permitted to obtain control of all the avenues of communication in certain districts, in restraint of trade, as some are now doing, and to overcapitalize the consolidated companies thus created, at inflated values, and thus place a double burden on the community from increased interest charges and higher rates.

The country needs restrictive as well as enabling legislation, and needs it soon, for the relief of the railroads as well as of the public.

DISCUSSION.

DISCUSSION—EPOCHS OF TRANSPORTATION.

MR. KELLOGG: Mr. President: There is a matter connected with what Mr. Haupt has been illustrating so ably that I would like to speak of, and that is the idea of some action by this society. His desire is that this society should, if it could find itself in a position to do so, urge that there should be legislation enacted for the purpose of stimulating work, under private capital and control, upon our waterways. Grants to private corporations as they were granted in the olden times, which we do not recall, any of us, to-day, have, of course, gone out of date. I do not think there is anybody here old enough to go back into the palmy days of granting privileges to parties to open canals and allow them toll for a limited number of years. It is Mr. Haupt's desire that we should, if we can, present such matter as we see fit in this line to the legislature of this state, or by memorial to Congress. I think I ought to say that, in my opinion, at least the society, or this convention at this time, will probably not find itself disposed or qualified to take up this question, that is, to take it up as intelligently as we would wish, on account of the other matters that are before us, and the limited time. But after what we have seen this afternoon, it has certainly been sufficient to set us to thinking very seriously on the matter. If we could do it in our work to-morrow, and bring the matter to a head, it seems to me it would be a very desirable thing to do. We can take home with us to-night and endeavor to digest what we have seen and heard. Then, at a subsequent meeting, we could bring the matter up and put it into such shape as the majority might see fit, either by agreeing to present a memorial to the state legislature or to the Congress, and see what can be done, for the relief of the congestion of traffic in various places. It would be a work, as it seems to me, well worth our undertaking.

THE PRESIDENT: Gentlemen, you have heard what Mr. Kellogg has said. It seems to me that this question of the conges-

tion of traffic is something very serious, particularly in our state, in connection with the railroads, for our waterways are limited in number.

MR. KELLOGG: Mr. President, I move that that subject be brought to our minds to-morrow for a short discussion if we have time.

Motion seconded and carried.

MR. HAUPT: Mr. President and Gentlemen: If you will permit me the floor for a moment, I should like to state what has been attempted in that line, and why it has not been more successful. In the state of New Jersey in 1876 the state legislature being, of course, under the practical control of the railroads, passed a law authorizing the construction of ship canals in that state. The first section of that law provided that no canal should be more than three miles long, and the last section provided that no canal pass through any incorporated town or borough of the state. You can readily see what such legislation as that amounted to. Now that same state of New Jersey is very anxious to procure the control of the development of the numerous inlets which indent the coast. For twenty-five years there has been more or less agitation, but in the absence of any legislation there has been very little accomplished. The state, however, last year, under Senator Dryden, asked Congress that it be allowed to take the control of its own waterways, provided that the state should not undertake any work where the national government itself contemplated improvements, and, in the second place, that it should not make any improvements under any plans unless they were submitted to and approved by the chief engineer at Washington, and in the third place, that they should not charge any toll upon any vessels using the improvements.

That is the character of the legislation that the state of New Jersey is enjoying to-day.

DISCUSSION—THE NEW HAVEN CUT.

THE PRESIDENT: Gentlemen, this paper is now ready for discussion, or for any questions which may be asked.

MR. JACKSON: There was one point, Mr. President, in Mr. Trumbull's paper that has occurred to me, and probably has to some others here, which it might be well to say a word about.

He was speaking of the arrangement or plan of the work which was brought about by a compromise between the city of New Haven and the railroad company. Of course, it is pretty well understood, I think, that that plan was drawn up by Mr. Kelly, a member of this society, and the city engineer of New Haven, and it was referred to a great deal in the course of the discussion on the matter, and the final plan that was adopted is due to Mr. Kelly. While some of the papers had it that the compromise plan was one that was suggested by the mayor and two members of the board of aldermen, who made up the committee for the city that settled the matter, yet it was really the Kelly plan. That part of Mr. Trumbull's paper was not as clear to me as, perhaps, to some of the others.

I would like to ask Mr. Trumbull, also, just one other question, and that is in regard to the run-off of one one-hundredth of an inch, if he thinks that that will be ample for all time, if a drainage system designed on that basis will meet the demands of the future?

MR. TRUMBULL: Answering Mr. Jackson's question, I would say that a rainfall rate of .01 of a foot per minute on the total Cut area was taken as governing the flow requirements of the pipe. The territory from Water street to Grand avenue is mostly built up, practically all the roof and street drainage going into the New Haven sewer system. From Grand avenue to Mill River the territory is largely open yards. In the first case it was assumed that only the water falling on the Cut area would enter the drainage system and in the second case that the runoff would be so far behind the rainfall that a pipe capacity sufficient for the Cut area would also take care of later inflow from outside territory.

The Cut area was divided into sections 100 feet long, the discharge for each section determined and the pipe dimensioned on this basis, the flow capacity being figured by Kutter's formula, with a slope of .00083 and N equal to .013.

THE PRESIDENT: One question occurred to me on the elevation of the lower part of the cut.

MR. TRUMBULL: The base of rail is, as I recall, about a foot below mean high water. The quantity of water which the temporary plant took care of during the excavation increased

very rapidly until it was necessary to run the plant night and day, but since the excavation the flow into the cut has been diminished so that now we are only troubled by an exceptionally high tide, or heavy rainfall; thus the temporary pumping plant will not be taxed to its capacity, but will do its greatest work only under such circumstances.

MR. KELLOGG: I would like to ask Mr. Trumbull about the base of rail. Is that one foot below mean high water?

MR. TRUMBULL: I am wrong about that. It is about a foot and a half. The dotted line on the plan is zero elevation, which is mean high water.

MR. KELLOGG: Do you know about what point it is in the Cut where the low elevation is reached?

MR. TRUMBULL: That is along in the territory near Chapel street.

SECRETARY JACKSON: There is another point in Mr. Trumbull's paper of particular interest to me, and, by the way, I would like to ask if Mr. Trumbull, or any of the other members, can give us any information about it, and that is as to the use of cast iron pipe for drainage systems of this kind. I know that on account of the extreme proximity of the tracks, it would probably make some difference with the durability of the system. I would like to know if systems of this kind have been installed elsewhere, and what the record of them has been. I did not know but Mr. Trumbull might know, or that some of the other members might know of similar instances. Probably Mr. Hill may know.

MR. HILL: Cast iron pipe is used frequently for culverts in railroad work. It is generally considered unsafe to use vitrified pipe.

MR. BURT: I do not understand clearly whether the manholes were built above the concrete and then put in place or just how that is. I would like to inquire of Mr. Trumbull.

MR. TRUMBULL: It was originally intended to build the ring of the manhole above ground and sink it to its final depth, but it was found later that that was not practical, and the excavations for the manholes are now sheathed; the concrete sides being built in place.

THE PRESIDENT: Gentlemen, is there any further discussion of Mr. Trumbull's paper. This is the end of our program for

the afternoon. If there is no further discussion, a motion to adjourn until to-morrow is in order.

MR. TRUMBULL: Just a word, Mr. President, in regard to Mr. Jackson's mention of Mr. Kelly's connection with the final layout. I wrote the description of the various lines in some haste and may have neglected to mention that the layout suggested by Mr. Kelly, known as the "Kelly Plan," was essentially the line finally adopted for the lower part of the city.

DISCUSSION—THE CHARTER OAK SEWER SYSTEM METHOD OF ASSESSMENT.

THE PRESIDENT: Gentlemen, are there any questions to ask Mr. Alderson?

MR. ALDERSON: I might state, Mr. President, in regard to this appeal that a judge of the superior court appointed a committee, who heard the case, and they made a report to the chairman. It is not exceedingly long. I think, perhaps, it may be of interest to some of you, and I will take the liberty of reading it.

VELHAGE'S APPEAL.

CONCERNING POWER OF COMMISSION TO ASSESS DAMAGES.

To My Associates on the Committee:—

In my opinion it is not the duty of this committee to suggest any special plan of re-assessment or indeed to suggest, in any way, how the town shall pay damages to the appellant in case this committee should decide to award such damages.

It is evident that the statute covering the rights of sewer commissioners, such as have acted in this particular case, has given authority to the special committee to be appointed by the Superior Court, to assess damages if, in their opinion, such damages ought to be assessed.

I am of the opinion that the method by which the assessments were made on owners of land in the Charter Oak System is as fair and equitable as it is possible to devise, under the existing circumstances.

The Charter Oak System must be considered as a whole, and it must, I think, be conceded that each individual owning property in that district has secured the right of outlet into the sewers of Hartford, for every acre and for every square foot on which he may hereafter build a house.

We do not undertake to affirm that Mr. Velhage's land is or is not as valuable as other land in that vicinity, nor is it our duty to estimate for him, either the expense of grading said land, the putting through of streets, or the expense of the various other operations which must possibly be undergone before his land shall be put in a condition to make it quickly marketable. We affirm, simply, that he, in common with all other land holders in that section, has secured the right of outlet, as above, and that it would have been a manifest injustice to him, to have excluded him from the possession and exercise of said outlet right.

With regard to the contention that a certain portion of his land, in making a mathematical assessment by the acre, should have been apportioned for streets and should not, therefore, have been assessed for this purpose of sewerage; I am of the opinion that such contention appears to reveal an inequality and injustice which could not well be remedied, either by the West Hartford Sewer Commission, or by this present committee.

No streets are in existence on said property, or have we any right to impose streets upon this land; incidentally, it may be noticed also, that if an allowance for street areas was allowed to this appellant, and to other owners of land in this locality, whose land is not already laid out in streets, the difference in the total amount of the assessment upon this appellant would not be great.

Another consideration of importance, is the fact that until such land shall become occupied by streets, as contemplated, the appellant has the continual use for farming purposes of all the proposed or possible street area while the owners of property abutting on streets already laid, and accepted by the Town of West Hartford, do not have such use of land already thus given up to streets.

With regard to trunk rights, I am of the opinion that the property of the appellant, in this case, has a real interest in all the trunk sewers actually existing in this district, and that the question of where he will hereafter enter such trunk lines not having been determined, or indeed, if it had been determined, has really no present bearing upon the question as to whether he should, or should not, be assessed in proportion to his land area for said trunk system.

It is manifest that land owners whose land abuts upon streets, such as Darcy, or Boulanger, will not probably enter the main line of sewer on Flatbush Avenue, yet they have been very properly assessed for their proportion of the cost of the trunk system.

Persons owning land abutting on Flatbush Avenue are not expected to ever make entrance into the Prospect Avenue main line, yet they have been properly assessed in proportion to their land area for the trunk line system. All owners of land lying within the limits of said Charter Oak System of sewers have already obtained immediate, not remote benefits from the outlet right, and from the trunk line system, which system was undoubtedly necessary to the successful and useful completion of the whole sewerage plan as it has been carried out in that district.

I am of the opinion that the Velhage property has a real and present interest in this whole system equal per square foot to that of any and all other properties within the limits of the said system excepting in one particular; it must be noted, that all the other large unimproved properties lying within the limits of the district abut upon trunk sewers in such a way as to make house drainage immediately possible throughout their entire areas, and all small lots of land are upon said streets already provided with sewers which run directly into trunk lines.

The Velhage property has a present actual opportunity for house drainage for only a small portion, i. e., 250 feet on Levesque Avenue. No trunk line has been laid either upon Oakwood Avenue or upon Levesque Avenue, or through the property itself, although evidence at the hearing given by A. B. Alderson, Engineer, of this very system and by others reveal the fact that before property of the said appellant can be properly drained a 10-inch sewer pipe must be laid either through Oakwood Avenue and through 600 feet, more or less, of the said Velhage's land, or else, beginning at a point on Oakwood Avenue within 350 feet of Levesque Avenue, a sewer must be laid to Levesque Avenue, thence easterly on Levesque Avenue something more than 500 feet, and then must be constructed through the said land to the limits either of the land of John Herne, on the south, or to the land of Patrick and Bridget Martin, on the east.

I am of the opinion that this committee has nothing to do with the possible cost to Mr. Velhage of securing a right of way through the land of Patrick and Bridget Martin, or through any other land because we do not know that such a right of way will ever be actually secured. It is possible that the said Velhage's land may be drained, in part through the 250 feet of sewer now on Levesque Avenue, and in part through Oakwood Avenue to Flatbush Avenue, or it may be suggested that property of the said Patrick and Bridget Martin and John Herne may be improved, i. e., cut up into streets and built upon, and sewers may be laid, long before the Velhage property shall be thus improved.

Having decided that the said Velhage property is benefited equally with all the others by securing the right of outlet and the right to use the trunk lines of this system, and is not within our province to decide how he shall avail himself of these privileges or to determine at what time, or with what expense he may so avail himself.

I am, however, of the opinion that, since witnesses for the appellant and for the defendant have admitted and testified to the fact that a trunk line sewer must be laid, either first, through the said Velhage property, or, second, upon abutting streets in part, and in part through said Velhage's property, the owners of land throughout this entire system of the Charter Oak Sewer district should have joined with the appellant in the expense, which is to be incurred in thus placing, for the use of his property, a trunk sewer, i. e., a sewer 2 inches larger than the said Sewer Commission of West Hartford settled upon, as the size basis of this entire system.

While it is impossible, as aforesaid, to determine exactly the number of feet of trunk line sewer which will hereafter thus be laid to make the entire system complete, and serviceable for each and every land holder, the appellant land holder included, yet, if we accept the plan which the West Hartford sewer commission has declared to be, in their best judgment, the best plan, at least 1,465 feet of 10 or 12-inch sewer pipe must be laid for this tract of land at a cost (considering the fact that said sewer must be laid a good deal of the way at a depth of from 15 to 18 feet) of from 15 to 25 cents extra per foot over the 8-inch sewer pipe which was adopted as the size basis of this system, thus making a total extra cost for the trunk sewer to properly and adequately complete this system of about three hundred (\$300) dollars.

It is my opinion, without going accurately into sewer estimates and calculations, such as manifestly cannot be made absolutely correct at this time, that the appellant in this case should be awarded, in the amount of three hundred (\$300) dollars.

(Signed) LESTER L. POTTER,
Chairman.

THE PRESIDENT: Mr. Alderson's paper is now before you for discussion.

MR. BUNCE: I would like to say a word or two on this matter as representing the other fellow. The man who made the appeal from this assessment was a client of mine. This is a matter which it strikes me may not be of especial interest to all of the members of the society, but those members who are connected with a city government or town government where sewer systems are laid out know that one of the difficulties necessarily attendant upon the laying out of sewers is an assessment to pay for their cost, and I think they all appreciate the difficulties that lie in the way of every one who tries conscientiously and fairly to make what, in his opinion, is a just, reasonable and proper assessment. It is a matter that for a great many years I had to deal with, and while I am now out of active operation in that line, I am still frequently called upon, in view of the experience that I have had, as an expert in this matter.

Now in relation to this matter before us, one thing which Mr. Alderson has not stated in reference to the agreement between the town of West Hartford and the city of Hartford was that no surface water should be permitted to enter the sewer system of Hartford, and that the system which was to be built by West Hartford must be confined entirely to house drainage. The

man whom I represented has a farm containing about 13.65 acres. It is as Mr. Alderson has stated, or as it has been stated in the report of the chairman of the committee, practically bottled up. That is, it has not any frontage or any existing sewer. And, by the way, let me say that so far as the plan of the assessment which was adopted by Mr. Alderson in this case is concerned, we had no contention. It seemed to be an equitable way of distributing the expense, but in estimating areas upon which these two items of one and two, on which we appealed, there was no attention to or notice taken of street areas in the district, and it seemed to us that that was a fair claim for exemption upon this particular property. It seemed so to me for two reasons: first, that it was utterly impossible for him to use this system of sewers until such a time as the property was cut up into building lots, and built upon, and second, then such a purpose should be carried out that he would then have no right to drain whatever surface might be taken for street purposes, and which was necessary in developing the property. A house could not be built upon that property situated the way it was until the streets were laid. I think Mr. Alderson is, perhaps, a little misleading in one statement that he makes where he says that the town of West Hartford had no knowledge where streets would be laid out on this property. Now if those of you who have a copy of the bulletin will look at the little map, you will notice upon that map a plot marked Velhage property, which lies in the upper right hand corner of the map, the dotted lines, as I understand it, representing two proposed streets. Those dotted lines, or proposed streets, were shown upon the official town map of the town of West Hartford as an exhibit in this hearing, and it seemed to me that the development, as suggested, was a fair, reasonable, and probable way in which that land would be cut up finally, if it was cut up at all. So that the town did have knowledge, in a certain sense, at any rate, what streets were to be laid out there, and where the streets should be. Now the surface covered by those streets as mapped out on the town map would measure about two acres. One of our claims was that after the street or surface had been taken into consideration in all other estimates of the area in the district that it was a fair exemption, or that a certain exemption should be made

upon that surface area. There were various propositions in the way of substitutes as to how this property should be drained otherwise than through these streets as indicated on that map, but I do not believe for a moment that Mr. Alderson or any engineer would suggest entering a system of sewers, or the use of a system of sewers from a quarter to half a mile long when the best grade could be gained at another point. In other words, if the sewers were built through the street, as proposed, they would enter the trunk sewer at its lower end, and naturally, of course, a better grade could be obtained than at a point very much higher. Now I have never heard, and I never knew what the reasons were that governed the committee in making the deduction in the assessment until I heard it this morning. I will say this in relation to this assessment, and perhaps that is the reason largely why the appeal was taken,—that the town of West Hartford had been reassessing property, and that they have, in a great many cases, raised the assessable value. Whether they have raised the value of this property, I do not know, but I notice that this property was assessed \$3,180, and assessment upon the elevated part, omitting the items upon which we made no contention, because there was a small corner of the property which abutted on a sewer, and upon which there was no appeal,—the assessment proposed on this land valued at \$3,180 was \$2,290, and it did seem to my client that that was almost a sacrifice of the value of the property to put such an assessment upon it. I think that was the reason we had for appealing.

Now, as I said before, in speaking of this matter, I have no criticism of the plan of assessment proposed here, because, as I said, at the beginning, it is one of the most difficult problems that an engineer has to contend with, and it is an ever varying problem. I do not know in all of my long experience as an engineer connected with a city government that I ever had two cases that were exactly similar. Each case had to be settled and studied out by itself, and it was the most difficult part of the work to fairly satisfy myself as to proper methods to pursue in order to equitably distribute sewer assessments.

MR. ALDERSON: Mr. President, of course, I do not like to take up too much time in connection with a matter of this sort, because I recognize that it may not be one which is generally

interesting to the members of the society, or one which will prove very instructive, but I would like the privilege of answering one or two of the points which Mr. Bunce has brought out, because I fear that perhaps a little misunderstanding may arise in regard to them. In regard to the dotted lines, showing the proposed streets on the official exhibit, that Mr. Bunce refers to, we simply had that in order to show the feasibility of planning the location and direction of the sewers, with reference to that property. Necessarily I had to show probable direction of proposed streets. I spoke with the owner about the matter several times, but it was impossible to get his ideas in regard to a definite sub-division.

MR. BUNCE: Just one word more. The opinion of the chairman of the committee awarding my client three hundred dollars damages, or a reduction in the assessment, was evidently not fully considered by the other members of the committee, as I believe that the grant actually given to my client was \$423.

MR. ALDERSON: I understand that the final adjustment is \$300. The other members of the committee have agreed to sign the chairman's report.

MR. BUNCE: I have seen published a statement that the reduction amounted to \$423.

MR. ALDERSON: I cannot explain the discrepancy.

MR. BUNCE: That is not the report of the committee. It is the report of the chairman to the other members of the committee, as I read it.

MR. ALDERSON: Well, it may be there was a reduction made later.

MR. BUNCE: I understand that \$423 was the reduction.

MR. BURT: Mr. President, this subject, as the last speaker has stated, is hedged about with all sorts of complications, and no two cases are alike. I had some experience with the sewer in Darcy street, which, as I understand, is near where this plant comes in or one of the outlets, and also the laying out of some property on a connecting street over here in the north end, so that I am somewhat familiar with the locality, and I think I can appreciate the difficulties that were labored under. Now as Mr. Bunce has said, there are hardly two assessment plans alike, and there are always a multitude of cases of apparent injustice. The principle of assessment here, in a general way,

by areas, would appear to be perhaps as fair as any, yet to my mind there would be some prominent objections, or exceptions to that rule. I would not use the term objections exactly, but put it exceptions to that rule. For instance, a certain exception would be in the case where the property was laid out in lots and streets. The corner lot property would in that case perhaps be unjustly taxed, and here in the city of Hartford, and I suppose it is so elsewhere, that principle is recognized. I think Mr. Bunce will bear me out in this, that if a man is entitled to sewer privileges, and if he owns the corner lot, that he should not be assessed on both streets, but should be assessed for the privilege of sewerage into the nearest competent sewer.

I do not understand from this little chart just where the outlet is to the Park Avenue system. I do not know as Mr. Alderson has indicated it on the plan.

MR. ALDERSON: One outlet is at New Park and Prospect avenues. The other at Prospect avenue and Merrill street.

MR. BURT: I do not know as I care to take up any further time. This is a subject which has more features which it would be interesting to discuss, but the main features are, of course, well understood. It has been stated clearly that every case is hedged about with many complications, and that is certainly so.

MR. HILL: Mr. President, there is just one point in Mr. Alderson's admirable paper that I think might be emphasized more. I notice that on page four he says: "Again, allow me to state that, in my opinion, too much importance cannot be attached to the privilege, or rather the right, I might say, which the property owners acquire to sewer their property at any time." That is certainly true. It is getting to be so now that property that is intended for residential purposes is not of very much value for those purposes unless it can be sewerage, and if the property can get those facilities they are worth in almost all cases a great deal more than the actual cost. That is something I think that is true in almost all cases; that the actual value to the property of sewerage facilities is almost always more than the actual cost.

MR. BROWN: Mr. President, may I ask one question? Of course, this owner who appealed for damages, or for a reduction in the assessment, had some land that would be greatly

benefited by drainage. Is there no way that he could enter his storm water into this sewer, and so get some benefit for the assessment that he pays?

MR. ALDERSON: I would state in answer to that question that our agreement with the city of Hartford prevented us from taking any surface water into that sewer.

MR. PALMER: One point occurred to me. In the report or paper I notice the statement is made that the treasury of the town of West Hartford pays no portion of this sewerage assessment. Of course, the amount of the appeal is only a small item,—three hundred dollars; but supposing it had been two thousand dollars? That would have been a very material portion of the cost of the sewer. How would that have been made up? Would it have been necessary to make a reassessment?

MR. ALDERSON: Well, I think I shall have to stand corrected, and state that the town treasury would have to meet such expenses.

DISCUSSION—DESCRIPTION OF CONCRETE CURB ON PARK TERRACE, HARTFORD, CONN.

THE PRESIDENT: Gentlemen, Mr. Clark's interesting paper is before you. Are there any questions?

MR. FORD: Mr. President, I wish Mr. Clark would explain just how that was put on. It seems to me that in concrete construction the finishing is a very important feature. Of course, it does not affect the stability of concrete structures, but it does affect the appearance of the work. I wish Mr. Clark would state how long the concrete was allowed to set before the wash was put on. In many cases where cement mortar is used there really is no union between it and the concrete work, so that this finishing is apt to be an important feature. I think we have there one of the handsomest artificial curbs ever laid in the city of Hartford. Mr. Clark has given a lot of time to it and taken a great deal of pains to see that he got it as nearly perfect as possible. I think that a little further explanation on that particular feature would be of interest.

MR. CLARK: What was the question?

MR. FORD: How long was the concrete set before you put on that washing?

MR. BURT: What thickness, or what was the final thickness that you put on in order to make the thickness of a sixteenth of an inch?

MR. CLARK: Why, there was no appreciable amount of plaster showing on the smooth work at all. No plastering was necessary to give it a good appearance. The surface was very smooth when the form was taken off, and it was then just rubbed over with the wash. No definite thickness was applied or any attempt made to get a certain thickness.

MR. BURT: What I had in mind was what peculiar advantage there was in a vertical profile curve except in cases of excessive change of grade? Is there a marked advantage, a noticeable advantage in the profile in this parabolic curve on a vertical curve?

MR. CLARK: Well, do you mean in comparison with a circular curve?

MR. BURT: Yes, sir.

MR. CLARK: Well, I think there is, and it is more convenient on an ordinary grade.

MR. BURT: And there is another point, Mr. President, that I would like to ask about, and that is, as to the length of these sections. I think you said in the paper they were ten feet.

MR. CLARK: Those are the Wainwright rails, those ten foot lengths.

MR. BURT: I have examined that work out there and it certainly presents a nice appearance. I was out there during its construction, and it is a very fine piece of concrete work set on a curve. It has been a question in my mind, however, just how that would compare with a granite curb in its wearing qualities and its durability. I think we have long sections of that in Hartford and vicinity. Mr. Henderson and others are very possibly more familiar with it, that is, more familiar with the actual wearing qualities and its durability, there having been some of it used in connection with the Connecticut River bridge and out toward East Hartford center. On that curb construction, this material was used I understand. I believe it was used for a distance,—well, it must be in the neighborhood of two miles, I should think. There is a case where the curb with this Wainwright border on the curb line has been in wear or in use for several years, but there is this difference

about it, the one I mention is set on a straight line while this is on a curve. I have noticed it as I have been going along by there in the car. I think it has stood the wear very well indeed. I do not know, from a close examination. I would like to hear about that from those who are more familiar with it.

There is one point in regard to this kind of construction that I would like to ask about, and that is in reference to the cost of such work. I would like to get some figures on that, if possible, in order that I might compare with the cost of granite curb. This method of construction is especially valuable in curved work, for we all know that the cost of cutting granite is excessive, and it adds very materially to the cost by having it cut on a curve, and especially on a sharp curvature. I do not know whether the comparison could be made with justice here, for the reason that the East Hartford curbs are all on a straight line and this is all on a curve. Still, it would be interesting to have some idea of what the cost of the straight part at East Hartford was. I do not know as that has been brought out. As far as ordinary observation goes, the curb stands well, although I have noticed in some places a deterioration, owing to the action, I should judge, of frost. The Wainwright rail is a decided protection to it. As to minimum depth of curb I am not quite clear. Practically a depth of a little over two feet in the gutter is a sufficient depth to protect from frost, or to protect it from the action of frost; still, we know very well that frost frequently goes into the ground nearly three feet in extreme weather. On the other hand, the ordinary curb about the city, and about all cities, I guess, is set very shallow, and is easily thrown out of place and has to be re-set. Of course, that must not be allowed in concrete work, because anything that would upheave would shake it to pieces. I would like also to have Mr. Clark explain a little the joining of the iron on top part of the curbs. I think it would interest me and other members.

MR. FORD: I might say that as compared to the cost of granite there was some reduction in the price. My impression is that the granite was from 91 to 93 cents. There was a little difference there. I am speaking with reference to that which was laid on the causeway. The work over on the causeway, however, was not to be compared with this.

MR. CRAWFORD: I have gotten \$1.14 for that curb and gutter. The gutter, I think, was twenty inches wide, about eight inches thick, and about ten inches at the edge.

MR. PHELPS: Mr. President, I would like to ask in connection with this discussion if anyone has had any experience with building of concrete curbing without angle irons. I built about fifteen hundred feet last fall on a residence street, and it looks as though it would stand.

I would like to ask also about the depth of the foundation. I notice that in all the concrete work here in the city that we have been used to putting in, there is a considerable depth of foundation, but in places along the shore where there is a sandy soil they put no foundation whatever. Some of the work which has been put in without any foundation seems to have stood just as well as walks with foundation, and if that is the case in sandy soil, it would seem to me that a curb might be put in with a good deal less foundation than two feet and make the cost a good deal cheaper.

THE PRESIDENT: Can any one answer Mr. Phelps' question?

MR. BUSH: In regard to breaking corners concrete curbs, I was talking some years ago with an engineer from western New York, and he was telling me his experience in that line of work. He said that he had built a number of miles of curbing without metal corners, and it had been very satisfactory. I am under the impression that he has laid eight or nine miles of it in different towns in western New York. He said it seemed to work all right. Possibly the real danger is less than is shown in the section gotten out by the Wainwright people. Possibly it would not look as well where it was built by the other method, but this engineer that I was talking with from western New York says it works all right.

MR. BURT: I suppose that would depend largely upon the wear or upon the possibility for wear. That is, especially on the corners, it would be well to have something to protect it.

MR. PHELPS: I should think it would stand except perhaps on the sharp corners.

MR. BURT: I think you would find that it would require the irons.

DISCUSSION—COMPLETION AND OPERATION OF THE NEW
HAVEN WATER COMPANY'S FILTER PLANT.

THE PRESIDENT: Mr. Ferry's paper is before you, gentlemen, for discussion.

MR. FERRY: This table which is attached at the end of the paper showing the percentage of removal of bacteria will perhaps not compare favorably with some other filters, but I think in the number of bacteria in the filtered water that the results are very nearly equal to the best records. The reason for this is that we have a very small number of bacteria in the applied water. Instead of having forty or fifty thousand bacteria per cubic centimeter in the applied water as they do in some places, we only have two or three hundred. Of course, under these circumstances we cannot expect as high a percentage. The highest number passing through, I think, is about 32. Since this paper was prepared, Mr. Connor has told me on two occasions that he has only found one colony in the filtered water; which is practically sterile.

MR. WHEELER: There are several points in this paper, Mr. President, that seem to me noteworthy, although I have not studied the subject very extensively; and one is with regard to the size of the sand. I understand Mr. Ferry to say that he thinks the finest sand gives a better effluent, and does not pass quite so much water as the larger sand, but gives about the same bacterial result.

In the table which is given upon page 37, the results seem to me remarkable. I have made a test of several spring waters, and of well water, and have found about fifty bacteria per cubic centimeter more than he shows, so that the purification seems to be quite gratifying. I would like to ask Mr. Ferry regarding the larger quantity that he found on the 27th of October,—2140 bacteria per cubic centimeter in the applied water. What circumstance would explain the larger number then? Was it due to any particular cause? Also regarding the cost of the filtered water—how does that compare with the cost elsewhere?

MR. FERRY: The date in October, October 27th, refers to a time following heavy rains, and the number is probably due to the washing of material into the water.

is left in the water; and that you will see, during the month of December, was very low indeed, varying from five to eight.

There is another point that might be interesting to call attention to, in relation to the cleaning of the filters. The usual method of cleaning is by scraping and washing the sand and replacing it. Mr. W. B. Fuller, with whom I was talking about the matter a few weeks ago, said that they were experimenting with simply washing the filter, that is, taking the filter and dividing it into sections, and allowing a stream of water to flow over it with considerable velocity. He said that the results were very good indeed, and the cost very much less than by the usual method of scraping and washing.

So I would say that the matter of the filtration of water is something in which improvements are being made all the while, and the end is not yet.

DISCUSSION—SOME TESTS IN SIGHTING AT LEVELING RODS AND STADIA RODS.

THE PRESIDENT: Gentlemen, Professor Tracy's paper is before you for discussion.

MR. BURT: Mr. President, there is just one point that I would mention, and that is about the value of this method. I have found occasions where in crossing streams in a preliminary survey for a railroad it was especially valuable and sufficient accuracy is often obtained by the use of such a method in that kind of preliminary work. As a rule, it is entirely sufficient. I remember very well my first use of the stadia, or when I was first introduced to it. It was at the time of the Connecticut River survey quite a number of years ago, I should say some twenty or more, and the work was carried on under the direction of General Theodore G. Ellis, C.E., who had a central office here. The value of the stadia in each case was determined by an accurate measurement on level places on our Bushnell Park, and by observation through instrument at every hundred feet. One objection to this method of determining the distance has been, to my mind, the liability of any transit to get out of adjustment, and especially of an older transit, in stumbling around in use in the fields. I remember one time, not many years ago, I attempted to determine the distance across a stream that would answer the purpose and the transit that I had

was one that had been in use for a good many years, and the matter of the stadia had not been looked over. I know from actual measurements, and a more careful survey that that was out several feet, and it was all occasioned by the transit.

MR. WHEELER: There are several things in this paper which are very interesting to me. Some years ago I happened to be at the Columbia Summer School of Surveying, when some measurements were made along this same line, although they were not made exactly for experimental purposes, but by way of laying out the work in courses taken by the students. A distance was measured of about eleven hundred feet, which is quite a long distance to take by this method, and an eighteen inch inverting telescope was used. The readings had to be taken between the middle wire and the outside wire. The readings were repeated—I do not recall now how many times, but the distances were afterward chained and the work verified, and the error was found to be about six feet. Of course, that work was done under pretty unfavorable circumstances and the error was about half a foot for every hundred feet.

I think that it would be instructive also if we had something to show the effect of the vertical angle, that is, whether it would introduce more error and the result be less accurate where distances have to be corrected for vertical angle than where measurements are taken on nearly level ground.

DISCUSSION—THE HIGHWAY BRIDGES ON THE NEW HAVEN IMPROVEMENTS.

THE PRESIDENT: I would like to inquire from Mr. Slocum in regard to the working stress in concrete and steel on those bridges, and whether there was need for reinforcing the bridges.

MR. SLOCUM: On account of the many kinds of old track material of widely different physical characteristics, used for reinforcement, the unit stress in the steel was kept quite low; 10,000 lbs. per square inch, under rather severe assumptions, was the limit. Under the same unfavorable conditions the unit stress in the concrete did not exceed 500 lbs. per square inch. As to whether it was necessary to reinforce these concrete bridges of the dimensions used, these arches are too flat to safely carry the loads, as gravity arches, without the reinforcement. This latter part of the President's question may be answered

indirectly by saying that the cantilever parts of these composite beams were able alone, without the concrete, to sustain the ordinary roadway loads; however, in the center beam carried by the cantilevers, or the flat center part of the arch, the concrete and steel together are necessary to sustain the loads within the limiting unit stresses.

THE PRESIDENT: Is there any further discussion of this paper? If so, it is in order.

MR. CLARK: Mr. President, I would like to ask Mr. Slocum if he took any measurements to determine the amount of settlement or depression in respect to the quantity. I noticed that remark that the centers were about an inch high in the case of these bridges.

MR. SLOCUM: There were some examinations made in levels to see if there were any settlement, and none appreciable was found.

MR. CLARK: In your opinion, if that element is made sufficiently strong, is it necessary to make any provision for a settlement?

MR. SLOCUM: It is better to do so.

MR. CLARK: It is on the side of safety. I can see that. You think it is better to do so?

MR. SLOCUM: Yes, I think so. It is the general practice in the erection of false work on bridges of this character to make some allowance for any possible settlement. However, the false work used for these bridges seemed to be plenty stiff enough to do its work.

THE PRESIDENT: I think an interesting question might be if any provision was made for expansion for the arches, if the arches expand, as they are said to do in some cases, it might be a very interesting question to know what the result would be, either for expansion in the steel work or concrete.

MR. SLOCUM: That is a question that was debated to a considerable extent at the time when these bridges were designed. There is enough steel in this work to take care of the expansion and contraction.

In a comparison of areas it takes about six-tenths of a square inch of steel to every square foot of concrete to withstand the effects of contraction and expansion, and in view of the conservative percentage of steel used in these bridges, it is

thought that temperature cracks will be prevented. It is rather a problematical question.

MR. JACKSON: Most of the concrete in the arches themselves was placed at one time, was it not? It was, as I remember it.

MR. SLOCUM: Yes, I think so.

MR. HENDERSON: I would like to ask Mr. Slocum in reference to the weight of the trolley car that he referred to. Was that the weight of a car that they assumed?

MR. SLOCUM: Why, I do not know as I remember the spacing correctly, but I have in mind that the heaviest car in present use was considered, that is, one of about 25,000 pounds on each of two axles, two axles to the truck, and two trucks. The axle loads are 5 feet apart, the trucks are 20 feet centers.

MR. HILL: I feel that we are very much indebted to Mr. Slocum for this detailed description of these interesting bridges. I notice that he speaks in one place about these arches acting very much as a composite steel bridge, that is, a cantilever arm and fixed span. In that case the bottom part of the reinforcement at the center would be in tension if this structure acted as cantilever. These two arms with a short fixed span, the bottom member of the fixed span would be in tension and consequently the bottom part of the reinforcement would be in this condition. I think that Mr. Slocum is safe in assuming what he has. It seems to me that the depth of the arch is so slight, and therefore the depth of the reinforcement is so slight, that the structure is more likely to act as a spandrel braced arch. In that case the bottom part of the reinforcement would always be in compression. It is problematical how any such structure would act, depending upon the loading. It seems to me it is more likely to act as a braced arch because for a uniform load I think that would be horizontal thrust.

As to the matter of using old scrap iron, and old rails, etc., for reinforcement purposes, that is exceedingly ingenious, and for the railroad it would appear to have been a very economical move. As this was an exceptional case, it was fortunate for them that they had plenty of this material, and in all probability it was economical for them to use as compared with the cost of getting new material.

I would like to ask Mr. Slocum if there was any objection as to using reinforced concrete in place of the girders. It is

with some slight shadow of regret that I notice that these comely arches were not carried throughout, when we take into account the effect of gases on the under floor of the steel system. I presume that the smaller cost of the steel bridges accounts for it, but the arches would have cost but little more when we take into account the maintenance.

MR. SLOCUM: Conditions are widely different in the higher east portion of this improvement than in the lower western half. In the eastern half with only four tracks to span there is barely enough depth for a satisfactory floor system for these particular bridges, consequently girders or trusses are used to an economical advantage, there being no necessity of spreading the tracks; but in the westerly half there is far less depth and twice as many tracks to be crossed, in the case of Chapel street 10 tracks; and since the total span of these bridges is more than double that of the easterly portion and with a depth barely sufficient for a 30 ft. span, no other recourse could be had in this lower western portion of the improvement than to spread the tracks to accommodate piers and make each street crossing a series of spans.

MR. HILL: Then, as I understand, the local condition there determined the form of the bridge?

MR. SLOCUM: Yes, I think so.

MR. KELLOGG: I would like to ask Mr. Slocum if he figured out the percentage of steel area, for instance at the crown of the arch.

MR. SLOCUM: About two per cent.

A MEMBER: He gives here a total use of 350,000 lbs. of steel and 1,550 cubic yards of concrete. It would be about $1\frac{3}{4}$ per cent. of the area.

MR. KELLOGG: Wouldn't that be the whole bridge, and not particularly at the crown of the arch?

MR. SLOCUM: That would be a comparison of contents of the whole bridge.

DISCUSSION—THE NEW CONNECTICUT RIVER BRIDGE
(N. Y., N. H. & H. R. R.) AT LYME, CONN.

THE PRESIDENT: Are there any questions to ask in regard to this paper?

MR. BUNCE: Will you tell me why you used those two spans?

MR. SOEHRENS: The 38-foot span is the roller bridge, and the 70-foot span just east of that is the bridge span for the draw.

MR. BUNCE: How far do they extend? About ten feet? I'm a little interested, as I go through there in a boat quite often.

MR. SOEHRENS: Keep the channel, and there is no danger of striking.

MR. BUNCE: One of the greatest improvements is the change in the grade of that bridge. I go down the river in a launch and at high tide it always gives me a fit until I get underneath that old bridge, it runs so close to the flagstaff, just about clears the beams.

MR. TURNER: Can you tell us when they expect to begin to use the bridge?

MR. SOEHRENS: I should say probably the latter part of May or about June, before they can run a train through.

MR. TURNER: For further discussion, I would like to ask in regard to the paper on the Connecticut River bridge. I notice that crushed stone was dumped into the piers, six, seven and eight, and subsequently piles were driven into that crushed stone. I would like to inquire what the object was in driving the piles into the crushed stone.

MR. SOEHRENS: Why, there was no covering. It was bed rock. Might have been six inches or a foot of mud, possibly; that was all. That seemed to be as easy and as good a way as any to get around it.

MR. TURNER: That doesn't quite cover the point. I don't quite understand about driving the piles.

MR. SOEHRENS: Why, they really don't act as much as piles as columns to rest on. The bottom of the piles is right on the rock; the rip rap is merely to keep them in that position. I wish to add that there was very slight settling in the construction of these piers, practically none, and to-day they are held and in first-class shape. I don't know as I have covered the exact point which you called for.

THE PRESIDENT: The question raised is, why was the crushed stone dumped before the piles were driven in?

MR. TURNER: Why were the piles driven in after the crushed stone? Couldn't the caisson have been on the stone without the aid of the piles?

MR. SOEHRENS: I don't know as I can answer that question myself, just as to why that was done. Of course, using the piles gives a much better and more satisfactory foundation than just the crushed stone alone, as it is much easier to get the top of the piles level, so that they won't warp the caisson.

MR. HILL: I would like to inquire as to the depth of the water. As I understand it, the rock was practically bare at that point, and whether the caissons could not have been sunk down to the bed rock and that rock leveled up, or was the depth too great?

MR. SOEHRENS: There was quite a depth of water and current. About eight feet of water. It would have been quite an undertaking to level off that rock there, to do it in a satisfactory manner.

The stone was about three-quarter inch size, and the piles drove through it without any great amount of difficulty.

DISCUSSION—SOME ENGINEERING FEATURES OF THE NORWICH HOSPITAL FOR THE INSANE.

MR. TURNER: I would like to ask if any provision was made in this concrete wall for draining the pockets back of the vertical portion to the base. I see no such provision in the plan.

MR. PALMER: I think there was some space left in there between each of the buttresses. The ground in back of that was very sandy material.

MR. CORSON: I would like to ask in regard to the construction of the power house. I think it was a plastered wall, but I don't understand the construction. I would like to know if it was a metal studding, or a wood studding on a wood sheathing. I would like to show how dry that wall has proved to be.

THE PRESIDENT: Do you know about that, the construction of the power house?

MR. PALMER: I can't answer that question. The power house construction was designed by Simpson Bros. Corporation, who built it. Since it has been built I have heard no complaints as to its dryness.

MR. CORSON: Is it built on a level against the studding, or against the sheathing?

MR. PALMER: I can't answer that.

DISCUSSION—LAYING OF SUBMERGED PIPES.

MR. HILL: I would like to know if these pipes have been tested for leakage, and if so, what the results were.

MR. WARDWELL: The pipe of the Housatonic Water Company was tested to 140 pounds. Mr. Brinsmade made the test.

MR. HILL: Do you recall what it amounted to?

MR. WARDWELL: There were two joints that showed just a little leakage, but that was afterwards closed up and they could not find any there when it was tested again. It had taken care of itself. The other pipes, of course, had no pressure.

MR. BURT: I think when this system of sewerage was first proposed in Stamford that they proposed to carry Akron pipes out, and I would like to ask Mr. Wardwell whether that was done. I think it was done at the time. My remembrance is that the stone pipes were carried out quite a distance.

MR. WARDWELL: There are no stone pipes beyond high water mark that I know of. There may have been sometime ago.

MR. BELDEN: I think that information is given in Colonel Waring's book on the Stamford system. I was interested in the execution of the work, and I think that matter is entirely covered in that book.

MR. BURT: Colonel Waring was the Consulting Engineer, and it was my impression that iron pipe was substituted; that the stoneware pipe didn't meet the requirements. I remember at the time Colonel Waring laid out this system that I was in the vicinity, and was given a copy of the specifications. They went in minutely, I know, to the laying of this pipe, and how the joints should be made, and there was to be a pumping station near the shore, and I think there was something like one mile across the flats to the delivery point; and I am especially interested to know how that succeeded. Evidently, it was found that the stoneware pipes didn't answer the purpose.

DISCUSSION—TELEPHONE SUBWAY CONSTRUCTION.

MR. WHEELER: I notice that down through Port Chester and Greenwich, where they were using creosoted wood that the ends were cone-shaped, and I suppose they were driven together to make a fairly tight joint. I would like to know

whether the ducts that were laid in that way were covered with concrete protection.

MR. EVERIT: The ducts in the section that was considered permanent construction were of tile laid in concrete. A large portion of the grades were not definitely settled, and as they could not get the permanent location for the ducts creosoted wood was used. It had no concrete encasement.

SECRETARY JACKSON: I didn't quite catch just what he said in regard to the abandonment of the aerial lines.

MR. EVERIT: I brought out that point with the idea of calling attention to the fact that aerial lines in the present state of the art cannot be abandoned. Connecticut probably has more, or as many, long distance lines in it as any other part of the United States, as it is in the through run between New York and Boston, and the state is crisscrossed by lines in every direction. The public, to a very large extent, suppose that the subway from New York to New Haven will result in taking down these aerial lines, but as it stands now, we do not see any prospect of being able to do this, even if the conduit is eventually completed to Boston.

MR. TRUMBULL: I should like to ask what is the shortest radius he can turn in with his vitrified conduit.

MR. EVERIT: We have never attempted to turn very short bends. There are tile bends made with a radius, I believe, of 18 inches, but they are only for use with very small cables. We avoid bends all we possibly can, and even put in manholes very often to get rid of them. The large size cables are too stiff to be pulled around sharp bends.

SECRETARY JACKSON: I should like to ask in regard to the development of manhole covers. We know that they first started in with manhole covers that were somewhat similar to the manhole covers or heads for sewer manholes of the circular type, and then they adopted a rectangular shape, and now on this new work I see you have gone back to the circular type again with many corrugations in it. It isn't a pleasant manhole to step on.

MR. EVERIT: Originally the covers were probably the same as the sewer manhole covers. I think they were exactly the same thing. We designed a square cover of our own of various sizes. That cover was not entirely satisfactory, being very heavy, and

one of the great objections to it was that men in lifting the cover off have dropped it into the manhole, and we have had several cases where cables were damaged in this way. The round manhole cover is, we think, better for general purposes.

MR. CORSON: He gives some very interesting historical sketches of the underground cable, and I have often wondered about the proposed system of ducts in the curbs. I don't know whether he knows whether it was ever tried or not.

MR. EVERIT: I don't think it ever was. It was put in in some sections in New York, but I understand it was never used.

MR. CORSON: Another thing; I was interested a few years ago in your talk on similar subjects, and in which you brought out your backyard distribution. Has that been followed?

MR. EVERIT: Yes, we have followed it.

MR. CORSON: Much objection on the part of property holders?

MR. EVERIT: Yes, we had, in getting the original permits. Where we have succeeded in getting these original permits it has been all right. We have had no trouble with any we have installed after it is once in, but they do object in the first place, fearing serious injury to their property, but after being installed it runs very smoothly.

THE PRESIDENT: What wires are carried in the subway between New York and New Haven? Only the local wires?

MR. EVERIT: The through cable circuits from New York to New Haven take all of the New York and New Haven business, also Bridgeport, South Norwalk and Stamford business, to and from New York.

THE PRESIDENT: Large wires?

MR. EVERIT: The wires are fairly large in these cables, No. 16 or No. 13 gauge. Anything beyond New Haven from or to New York does not go through the cable, only short haul business.

THE PRESIDENT: I saw a case of some wires, electric light wires, being carried across a little stream in an iron box. I noticed it was carried in a wood fibre pocket laid in concrete. Now, I wondered why it was laid in concrete—why they couldn't be laid in sand?

MR. EVERIT: I assume you mean in using ducts. We have considered doing away with the concrete encasement. If the ground is fairly stable, we can get along without any concrete

at the bottom. The concrete at the top is largely for a protection against mechanical injury. In multiple ducts we frequently leave out the concrete on the sides.

THE PRESIDENT: In New Britain, sometimes they want to get down into the subway, and have to dig out the concrete, and I have wondered if there was any way that the ducts could be laid without any concrete. But I understand that it has to be used as a protection.

MR. EVERIT: Yes, by making it hard to dig through.

THE PRESIDENT: They have to sometimes.

MR. JACKSON: The conclusion that we are to come to from Mr. Everit's paper is that the dream of all municipal engineers of a large subway in which the wires of the different companies, such as telephone and electric light companies, and the pipes of the different private corporations, such as gas, is a dream which, as I say, from his paper, we will never see realized. It is practically not feasible, as I understand it.

MR. EVERIT: From the experience of those who have tried to do it, I should say not.

MR. BURT: What means is used to locate a fault in the wire? I understand that in the subway there are ways of accurately locating a fault.

MR. EVERIT: All tests for locating faults from grounds depend, of course, upon the resistance of the wire. We know what the resistance of each size of wire is per foot, and we have methods of measuring which give us the resistance from the end of the cable to the ground. We then calculate the distance to the ground. We find that we get very accurate results and in a case of trouble the other day—the fault in a cable several miles long, was located within some twenty-five or thirty feet of where it was actually found and that was not an extraordinary case.

THE PRESIDENT: If there are no further questions on this paper, this ends our regular program.



JOHN W. BACON.

JOHN WATSON BACON.***In Memoriam.***

The death of John W. Bacon at his home in Danbury, Conn., Feb. 27 1907, closed a long, useful and honorable life, full of notable work, well done.

Mr. Bacon was a man of simple, refined tastes and of the strictest integrity. He had unusually clear, sound judgment; and his counsel was much sought for and highly valued by his business associates. He was always deeply interested in engineering progress and solved in an able manner the special engineering problems that came under his direction. He took an earnest and helpful part in the civic work in his community.

By his death the Connecticut Society of Civil Engineers has lost one of its earliest and most respected members.

John Watson Bacon was born in Hartford on June 9, 1827, and was therefore only a few months less than eighty years of age. He was a son of Leverett W. and Sarah Watson Bacon. He received his preliminary education in the public and private schools of Hartford and was graduated from Trinity College, Hartford, in 1846. He was then nineteen years old and he received the first appointment in his class and was its valedictorian.

Mr. Bacon's first important work as an engineer was laying out and constructing between Hartford and Willimantic what is now the Highland division of the New York, New Haven and Hartford railroad. It was then a part of the Boston, Hartford and Erie project and subsequently became the New York and New England railroad. His work included the construction of the bridge across the Connecticut river near Hartford and the union station in Hartford, which has since given way to the present station in that city. Immediately following the completion of this work, Mr. Bacon began the survey for and superintended the construction of the Danbury and Norwalk railroad, which was begun in 1850 and completed in 1852.

This road is now the Danbury branch of the New York, New Haven and Hartford road. In 1852 Mr. Bacon went to Hartford and became superintendent of the Hartford, Providence and Fishkill railroad, which subsequently became a part of the New York and New England system and later was absorbed by the New Haven road.

Mr. Bacon continued the superintendency of this railroad for five years and then went to West Virginia to aid in the development and operation of extensive coal mines and salt works which were being opened at West Columbia, on the Ohio river. After being engaged in this enterprise two years he returned to Connecticut and took up his residence in Danbury.

He was superintendent of the Danbury & Norwalk Railroad from 1859 to 1877. Under his skillful management, this railroad was greatly improved and developed. Under Mr. Bacon's direction, the Ridgefield branch, from Branchville to Ridgefield, was constructed in 1869. He also supervised the building of the Shepaug Railroad, now the Litchfield branch of the New Haven System, in 1872.

Governor R. D. Hubbard appointed Mr. Bacon a member of the state board of railroad commissioners in the fall of 1877. He served with honor and credit upon this board for ten years. He also served as one of the State Commissioners of the topographical survey and map of Connecticut.

In 1877 he was elected a member of the American Society of Civil Engineers.

Mr. and Mrs. Bacon were very faithful attendants upon the annual conventions of the American Society, and took a very enthusiastic and intelligent interest in the excursions to inspect works of engineering interest.

Mr. Bacon was one of the charter members of the Connecticut Society of Civil Engineers, when it was organized in 1884.

One of the most important public works with which Mr. Bacon was connected was the Kohanza water system of the city of Danbury. This system was constructed under the direction of Mr. Bacon in 1860, and he had supervision of it for sixteen years.

Mr. Bacon was President of The Savings Bank of Danbury from 1893 to the time of his death. He was also President of

the Danbury Mutual Fire Insurance Company; and the Wooster Cemetery Association. He was a Director in the Danbury National Bank; a trustee of the Library Association; and for many years connected in official capacities with the schools of the city and town.

Mr. Bacon was closely identified for many years with the Danbury fair and his zeal and energy in the interests of that institution was largely instrumental in its success. He was one of the leaders in the movement which brought about the reorganization of the Danbury Farmers' and Manufacturers' company, which controlled the fair previous to 1871, and when the Danbury Agricultural Society succeeded the old organization in that year he became its first president, continuing in that position three years. He subsequently became treasurer of the society, a position which he held for thirty-seven years.

He had been chairman of the Society's committee of the First Congregational Church twenty years, and was prominently identified in various ways with the affairs of that church, at the services of which he was a regular attendant.

In these and many other ways Mr. Bacon was for many years a notable figure in Danbury life. He kept closely in touch with all phases of public activity and upon financial, business, and municipal matters was one of the most thoroughly informed men in the city.

On Dec. 20, 1852, Mr. Bacon married Caroline E. Botsford, daughter of Dr. Russell B. and Eliza Whittlesey Botsford. Dr. Botsford was for many years a leading physician of Danbury. Mrs. Bacon died in March, 1903. Mr. Bacon is survived by three children,—Miss Sarah W. Bacon, Mrs. G. Mortimer Rundle, and Dr. John R. Bacon, all of Danbury.

ALBERT B. HILL,
ELY M. T. RYDER.



WILLIAM B. COCHRANE.

WILLIAM BACHELDER COCHRANE.***In Memoriam.***

William Bachelder Cochrane was born at Haverhill, Mass., on the 14th of October, 1833 and died at Stamford, Conn., on the 12th of July, 1906.

Mr. Cochrane was graduated from the Sheffield Scientific School in 1853, his class being the second graduating class in the history of that institution, consisting of seven members only: one member of this class still survives.

After concluding his college training he went west and there practiced his profession.

At the outbreak of the Civil War, Mr. Cochrane was located in the State of Illinois, and enlisted in a volunteer regiment from that state on May 22, 1864. He saw much active service, and at the conclusion of the war engaged in business with his father, who was a shoe manufacturer in Boston. Later, Mr. Cochrane bought a farm in Westboro, and conducted that for a few years, after which he came to live in New Canaan in 1878. While living in New Canaan, he conducted a farm at Tallmadge Hill.

In 1883 Mr. Cochrane came to Stamford, and was actively engaged in his profession up to the time of his last illness.

He was for a time Borough Engineer, and later, was for several years City Engineer, when the city government was substituted for that of a borough.

For the last six years of his life he was engaged in private practice as civil engineer and surveyor, his business extending into adjacent towns in addition to an extensive local practice.

Mr. Cochrane was ever courteous to all, was a good citizen, and had high regard for, and abided by, the ethics of the profession. His genial disposition was recognized and admired by all who knew him.

He was twice married and leaves a widow to mourn his loss. He had one son (now dead) by his first wife.

Mr. Cochrane was active in Grand Army circles, and was a member of John Hancock Lodge, F. and A. M., of Massachusetts.

He was elected a member of the Connecticut Society of Civil Engineers on January 14, 1890, and continued a member until his death.



BENJAMIN F. HATHAWAY.

In Memoriam.

B. F. Hathaway, who was born at Suffield, Conn., January 7, 1827 and died at Stamford, Conn., March 3, 1906, was a graduate of Suffield Institute. After graduation he taught school in his native town until 1852, when he began the practice of his profession as a civil engineer, making a specialty of cemetery work. Among the many cemeteries laid out by Mr. Hathaway are those of Poughkeepsie, Fishkill, Hyde Park, Newpaltz and Auburn, in the state of New York; Carbondale, Pennsylvania; Dover, New Hampshire; Suffield and Stamford in Connecticut. Mr. Hathaway was working on the landscape effects of the Springdale Cemetery at Stamford when taken with his last illness. He lived the life of a quiet, retiring citizen, was highly respected, and was a member of the Masonic Lodge at Suffield. He leaves a widow and two children; one a daughter, Clara R. Hathaway, who is a teacher of art in the Jamaica Training School of the New York City school system; the other, a son, Charles R. Hathaway, an attorney in New York.

PAUL NASH,
HAROLD A. PARSONS,
FREDERICK WARDWELL,
Committee.



ARTHUR P. LAW.

ARTHUR PRICE LAW.***In Memoriam.***

Arthur Price Law died at East Providence, Rhode Island, on Monday, November 19th, 1906, after a short illness, of typhoid fever.

Mr. Law was born on July 7th, 1870, in New York City, attended the public schools and high school in Flushing, Long Island, and was a graduate of the civil engineering course of the International Correspondence Schools, of Scranton, Penn.

He first worked as assistant on Government surveys in Florida. From 1893 until 1900 he was in the employ of the N. Y., N. H. & H. R. R. Co., first on the drawbridge at South Norwalk, Conn., then on the Fort Point Channel drawbridge in Boston, Mass., and for a short time on the Railroad Improvements at Bridgeport, Conn.

In 1900 Mr. Law entered the employ of Holbrook, Cabot & Rollins as superintendent of construction, in charge of deep foundations and substructure work, and was in their employ at the time of his death.

During the seven years of his connection with the Holbrook, Cabot & Rollins corporation he had charge for them of the foundations for a double track railroad bridge at Tiverton, Rhode Island, and the work along the water front at Bridgeport, Connecticut, done by this corporation. He started the work on the Housatonic River foundations, and then went to the Connecticut River, at Lyme, and completed the work on the deep foundations there. Later, he took up the matter of the foundation for bridge at Neponset, Mass., and also for the bridge across the Teekonk River at Providence, Rhode Island.

His work was carried through with marked ability and success, and without any trouble or loss either to the Railroad Company or the Holbrook, Cabot & Rollins corporation, and was done to the utmost satisfaction of both.

Mr. Law was an associate member of the American Society of Civil Engineers and belonged to the Order of Red Men. He was elected a member of the Connecticut Society of Civil Engineers on February 9th, 1904.

R. F. STODDARD,
J. H. SOEHRENS,
M. S. JAMESON.

REPORT OF PROCEEDINGS
AT THE
TWENTY-THIRD ANNUAL MEETING
OF THE
Connecticut Society of Civil Engineers.

The twenty-third annual meeting of the Connecticut Society of Civil Engineers was called to order at Knights of Pythias Hall, Hartford, Connecticut, February 12, 1907, President Charles F. Chase, of New Britain, in the chair.

THE PRESIDENT: Gentlemen, you will please come to order. The constitution provides that the ballot for officers closes at eleven o'clock. The ballot is therefore closed for the election of officers.

The first business is the reading of the minutes of the last meeting.

SECRETARY JACKSON: Mr. President, I move that inasmuch as the minutes of the last meeting are printed in the regular proceedings, that the reading be dispensed with.

MR. FORD: Second the motion.

THE PRESIDENT: Gentlemen, it is moved and seconded that as the minutes have been printed, that the reading of them be dispensed with. All those in favor will manifest it by saying "Aye." It is carried.

The next thing is the report of the Board of Direction.

Secretary Jackson read the report of the Board of Direction as follows:

REPORT OF THE BOARD OF DIRECTION.

A meeting of the Board of Direction was held at Hill's Homestead, West Haven, on June 29, 1906, at 4 P. M., at which time the following business was transacted: The resignation of Theodore Wirth was accepted. Four members were dropped. It was voted to hold the summer meeting of the Society on the Connecticut river; that the arrangements therefor be left to a committee to be appointed by the President, they to be limited to an expenditure of \$100.00. Those present were Messrs. Chase, Brinsmade, Bush, Kellogg, Crandall, Punderford and Unkelbach.

At a meeting of the Board held on the steamer "Madeleine," on the Connecticut river, August 14, 1906, the following names were recommended for membership: Charles Y. Bennett, Hartford, Connecticut; Edwin P. Dawley, New Haven, Connecticut; George R. Johnson, West

Haven, Connecticut; Robert L. Pearson, Saugatuck, Connecticut; Albert H. Schilling, New Britain, Connecticut; Philip K. Williams, Glastonbury, Connecticut.

Messrs. Nash, Wardwell and Parsons were appointed a committee on Necrology of William B. Cochrane, of Stamford.

At a meeting held in the City Hall, New Haven, at 2.30 P. M. the resignation of Herbert M. Knight was accepted. It was voted that the annual meeting be a two days' session; that it be held in Hartford, February 12 and 13, with the annual banquet on the evening of the 12th; that the arrangements be left to a committee appointed by the President; that the sum of \$150.00 be appropriated for expense of annual meeting. The ballots for nominations were canvassed and resulted as follows:

President, D. S. Brinsmade, Derby, Conn.

1st Vice President, Edward W. Bush, Hartford, Conn.

2nd Vice Presidents, { Frederick J. Easterbrook, New Haven, Conn.,
Francis H. Oldershaw, New Britain, Conn.

Secretary and Treasurer, J. Frederick Jackson, New Haven, Conn.

Board of Direction. { Charles F. Chase, New Britain, Conn.,
Henry J. Kellogg, New Haven, Conn.,
Paul Nash, Stamford, Conn.

Voted, that the matter of registration be referred to a committee comprising Messrs. Brinsmade, Luther and Crandall. Present, Messrs. Chase, Bush, Brinsmade, Kellogg and Crandall.

At a meeting held in Knights of Pythias Hall, Hartford, February 12, 1907, the resignations of H. E. Bushnell, G. E. Catlin, S. R. Higgins, H. M. Knight E. R. Ingraham, E. J. Rungee, H. B. Seaman, H. H. Smith, E. L. Verveer, were accepted, the following names approved for membership: Reuben B. Azhdarian, Waterbury, Conn.; Daniel William Bleim, Hartford, Conn.; Willard Seymour Brewer, East Hartford, Conn.; Grey Willis Curtiss, New Haven, Conn.; William Robert Dunham, Jr., New Haven, Conn.; Charles Ernest Hall, New Haven, Conn.; William Henry Hall, New Haven, Conn.; Alexander Joseph Hans, Stamford, Conn.; Irving Warren Harrison, Waterbury, Conn.; Timothy Andrew Hulbert, Waterbury, Conn.; Leon Kopczynski, New Haven, Conn.; C. T. Lyon, New Haven, Conn.; Thomas McKenzie, Westerly, R. I.; Robert Collyer Noerr, Hartford, Conn.; John Olsen, Springfield, Mass.; Walter Poelhandt, New Haven, Conn.; Charles Henry Preston, Jr., Waterbury, Conn.; Charles Edwin Rogers, Hartford, Conn.; Clifford Anson Root, Hartford, Conn.; John S. Ruff, New Haven, Conn.; Paul Sheldon, Hartford, Conn.; and the books of the Treasurer audited and approved.

Signed,

HENRY J. KELLOGG,
EDWARD W. BUSH,
GEORGE K. CRANDALL,
CHARLES F. CHASE,
Board of Direction.

Attest:

J. FREDERICK JACKSON, *Secretary.*

THE PRESIDENT: Gentlemen, you have heard the reading of the report of the Board of Direction. What will you do with it?

MR. FORD: Mr. President, I move it be accepted and placed on file.

Motion seconded.

Motion carried.

Next is the report of the Secretary.

The report of the Secretary was read by Mr. Jackson as follows:

REPORT OF THE SECRETARY FOR THE YEAR ENDING FEBRUARY 11, 1907.

To the Officers and Members of the Connecticut Society of Civil Engineers:

Your Secretary respectfully submits the following report for the past year:

In May, thirteen hundred copies of the Twenty-second Annual Proceedings were printed and distributed to the members, to those societies with whom we exchange, and to different libraries and institutions of learning. The Society held one additional meeting on August 14, a trip up the Connecticut river, which was much enjoyed by those present. The Secretary has during the year attended the different meetings of the Board of Direction; has had printed and distributed notices of the different meetings, bills for dues and advertising, and the ballots for nominations and election of officers. The canvass of nominations resulted as stated in the Report of the Board of Direction. During the year twenty-one new members have been elected, twenty active and one honorary. Three members have resigned. Five have been dropped. One honorary, Ben. F. Hathaway, and two active, Wm. B. Cochrane and Arthur P. Law, have died. The membership on February 11, 1907, is as follows:

SUMMARY

	Feb. 12, 1906.	ADDITIONS.		Deaths.	LOSSES.		Feb. 11, 1907.
		Transfers.	Elections.		Resigned.	Dropped.	
Honorary	11	....	1	1	....	....	11
Active...	246	....	20	2	3	5	256
Associate	8	....	..	....	....	....	8
Totals.	265	....	..	....	....	....	275

THE PRESIDENT: You have heard the report of the Secretary. What is your pleasure?

MR. KELLOGG: I move you, Mr. President, that the report be accepted and recorded.

Motion seconded.

Motion carried.

Next is the report of the Treasurer.

The report of the Treasurer was read by Mr. Jackson as follows:

REPORT OF THE TREASURER FOR THE YEAR ENDING FEBRUARY 11, 1907.

J. Frederick Jackson, Treasurer, in account with the Connecticut Society of Civil Engineers.

RECEIPTS.

To cash on hand, February 12, 1906.....	\$528.80
Received from advertisements, 1906.....	180.02
Received from advertisements, 1907	10.00
Received from back dues.....	57.30
Received from dues, 1905.....	99.00
Received from dues, 1906.....	528.00
Received from dues, 1907.....	246.00
Received from sale of reports.....	1.00
Received from sale of dinner tickets.....	224.00
Total	<u>\$2177.82</u>

DISBURSEMENTS.

By Cartage.....	\$ 4.10
Expressage	82.86
Freight	11.49
Expenses annual meeting	325.85
Postage	1.88
Printing, stationery and supplies.....	584.56
Rent, P. O. box	4.00
Engraving	46.19
Services of stenographer.....	35.00
Stereopticon	8.00
Salary, Secretary	100.00
Summer meeting	181.60
Typewriting	7.33
Messenger	.30
Transportation	1.75
Balance February 11, 1907.....	782.91
Total	<u>\$2177.82</u>

February 12, 1907.

This is to certify that we have this day examined the accounts of the Treasurer and found the same correct.

EDWARD W. BUSH,
HENRY J. KELLOGG,
CHAS. F. CHASE,
GEO. K. CRANDALL,
Board of Direction.

THE PRESIDENT: Gentlemen, the report of the Treasurer is before you. Any remarks?

A MEMBER: I move that the report be accepted, Mr. President, as read.

Motion seconded.

Motion carried.

MR. KELLOGG: I believe, Mr. President, we should have a report from the Committee on Necrology.

THE PRESIDENT: Mr. Jackson, are there any members of the Committee on Necrology present?

SECRETARY JACKSON: I do not think there are, Mr. President. Their report, of course, will appear in the annual proceedings.

THE PRESIDENT: If there are no special committees to report, I would like to say under this head that a committee was appointed, consisting of Messrs. Brinsmade, Luther and Crandall, to take up the matter of the proposed bill in regard to licensing engineers and surveyors. They were appointed as a committee by the Board of Direction at one of the recent meetings, and we should have something from that committee when we introduce miscellaneous business. The object or purpose of the bill has been explained in a circular which has been sent out. I think most all of you have received copies of the bulletin which was issued, and all have had a chance to look it over.

We now come to the election of new members.

MR. BUNCE: Mr. President, I move that the rules be suspended and that the Secretary be authorized to cast the ballot of the Society for the names as read by him. As I understand, the names of all of the nominees which he read have been approved by the Board of Direction.

Motion seconded.

Motion carried.

THE PRESIDENT: I will appoint as tellers, Mr. Belden and Mr. Corson. There are 21 new members, and their names can hardly be deposited without taking a few minutes, and making out the list.

SECRETARY JACKSON: I do not think that is necessary, Mr. President. The ballot is ready now.

THE PRESIDENT: The Secretary says that the ballot is ready on the election of new members. The tellers report that the Secretary has cast one ballot for all new members. I do not think it is necessary to read the names, as they are all published in the program, and I would therefore declare that those names as printed have been elected members of the Society.

The next business in order is the election of officers. I would say that Mr. C. H. Olmsted of East Hartford and Mr. Clinton L. Cole of Hartford were appointed tellers, and they have been for some little time canvassing the ballots. As soon as they are ready to report, we will be able to announce the new officers.

The next in order is the address of the President.

The following address was then delivered by President Chase:

ADDRESS OF THE PRESIDENT.

Gentlemen of the Connecticut Society of Civil Engineers:

A short time ago I had the pleasure of listening to one of the country's greatest educators and statisticians on the subject, "The Public Conscience." During his talk he asked if any one of his audience could state where a man should go if he wished to be free from such a conscience and its attendant conditions. Receiving no reply, he said that there was just one country in the world and that was Patagonia. There they have no jails, no police, no crime, as we know it, and no society; all of these being results of our conscience and civilization.

Should the question be asked, where should one go and not find an engineer, it would be a far more difficult question to answer. I think that I can safely state that engineers have invaded every country on the globe. Even Patagonia knows them, and the results of their work and labors are before us at all times and in all places.

Imagine one of the native Patagonians transported from the quiet and conscienceless surroundings of his own land. We will assume that he has journeyed many long days, and in the dusk of the departing day the vessel bearing him is entering the harbor of the greatest of America's seaports. New York, by night, with its myriads of lights extending from the sea line to the lofty altitudes of the storied buildings, would be a sight never to be forgotten. Little would he imagine that the greatest engineering abilities are involved in the production of many of the sights that are spread out before him. He has landed; and the rush of cars overhead and the rumble of cars below cannot but show him that he has entered into a new world and a new life. Let us enter the subway, one of the greatest engineering achievements of the present day; a few minutes later, at 42nd street, the immense work of the New York Central Railroad stands as an example of man's struggles in one direction. Further on to Times Square, and a monument of the engineer's ability and cunning rears its 25 stories above the street. Who would guess that the same structure extends for four stories more below the sidewalk on which he treads? Toward the south, the "Great White Way," a blaze of light dazzles his eyes, and the vastness of the thing is almost beyond belief or description.

All this is the result of engineering of one kind or another.

Transportation, the various constructions and electricity, all are dependent for their existence and being upon the skill of the engineer, and the forces that have been made subject to him.

Ninety-eight years ago to-day there was born in a backwoods town in Kentucky, a man the whole nation learned to revere. With the limited means and opportunities offered to him, Abraham Lincoln, at one time in his life, became a surveyor. The histories of this great and good man picture him standing in position behind his compass, and I am sure that the lines he ran and the plots he surveyed, with his simple instrument, stand as monuments of his accurate and intelligent work.

At this, our twenty-third annual meeting, we are again gathered together and should congratulate ourselves on living in this age of progress and civilization.

As the "public conscience" is the result of education, so is the science of engineering. We have much more than our predecessors of a hundred years ago, and we want more, yet our wants do not seem even yet to be satisfied.

We call ourselves a "Society of Civil Engineers," but interpret the words broadly enough to include the engineers of allied lines of work. It is well that we do this, for our Society would be inclusive rather than exclusive. It is not necessary that a man should be simply an expert in running a level or compass, or in gauging the flow of the stream, to become a member. If he has achieved anything that adds to the engineering knowledge of the world, or has shown his ability in surmounting nature's obstacles in any of the varied and kindred lines, his place is surely in our ranks.

Two tin cylinders with diaphragms of sheepskin, a string across the street, and we have our first telephone. We can now sit at our desk or in our own house and can talk with our business acquaintances or friends who are located hundreds of miles away. We can call this "Telephone Engineering," if you please, and no obstacle has yet been able to resist its onward march toward perfection.

The farmer, at his own home, used to make his own tallow dips in the fall of the year, all of the materials being strictly of home production. If we cannot now turn a switch and throw a flood of the purest light, we are not satisfied. It is only by utilizing the power of the stream or the heat from the coal that this result has been attained. This is "Electricity" and "Electrical Engineering," a branch of engineering almost by itself, and the end is not yet.

The mariner on the ocean, far out of sight of land or beacons, catches the vibration of the air and transforms it into a message of welcome. He is no longer alone, even though his vessel is separated from any other by hundreds of miles. What shall I name this, "Telegraphic Engineering?"

Little by little, the power and knowledge of man is surmounting the forces of nature and bringing them into his service. The immensity of some of man's achievements is hardly within comprehension, and there seems to be no obstacle which cannot be overcome by his cunning. Even now we read of the seven wonders of the world, one of which was the Pyramids of Egypt. In the building of the great Pyramid of Cheops it is said that thousands of slaves were employed for many years. This is a pygmy among our present day achievements. The output of the city of Pittsburg, including steel, coal and glass, would construct a Cheops every four weeks. And to what is this result due? In great part to the energy and invention of the engineer, under whose guiding hand the earth is made to give up its riches and to send them forth into all the world.

Our membership at the opening of this meeting was 264, and we have just elected 127 new members, so that we now have a total membership of 391, the highest we have ever reached.

While our state is small, every part and portion of it is full of industry, and we should be proud of it. We have several great engineering works under way, and shall hear of some in detail before the end of this meeting. It is, however, but fitting that some of them should be mentioned here.

To begin with our great railroad system, the "Consolidated," controlled as under its management is now combined all the rail transportation of the state. The electrification of the section of steam road adjacent to New York City is well under way, and there the most modern products of the electrical engineer will soon be at work. Going north and east are the new railroad bridges over the Housatonic river at Naugatuck Junction, and over the Connecticut at Lyme. At this latter bridge, when the lift span is in the fully open position, the second floor beam from the end is at the height of the clearance line of the old Franklin bridge. The New Haven Quonset, which has been long contemplated, is now being fully realized. These are, all of them, undertakings of enormous magnitude, and perhaps those who are not on the inside of our railroad management wonder what next.

We have all heard of the "Consolidated Railway Company," a corporation closely related to the "Consolidated," and which has set itself out to make a unit of the various gas, oil and electric lines of this state and its neighbors in the east and north. Most of the heads of this system and those in charge of its engineering are members of our Society, and we are proud of them. While our management does not always, as it is said to do, tell them how to do their work, it does tell them when to do it, and when, of course, to stop. It is not a very pleasant job, but it is the one that we are all to make them do, and it is a job that is well paid for us in this day of progress.

Going back to the Naugatuck bridge, the new lift span bridge over the Connecticut river, we are going to hear of it, and while we shall have no opportunity to hear of it from the lips of our members, during the session, we shall hear of it from the lips of our engineers in charge of its construction. So, I am sure they will welcome the opportunity to tell us of it. The lift span is always out of the way, and it is a very interesting work.

There are also several new systems now being installed in the state, and we shall hear of them from New Britain and Saybrook. The new system at Saybrook, when completed, we shall hope to hear of it from the lips of our members. The new system at Saybrook is a very interesting work, and it is a very interesting work.

There are also several new systems now being installed in the state, and we shall hear of them from New Britain and Saybrook. The new system at Saybrook, when completed, we shall hope to hear of it from the lips of our members. The new system at Saybrook is a very interesting work, and it is a very interesting work.

ceed too fast. With the great number of systems of concrete-steel construction there may not be any one that is better than all the rest, but several of equal merit.

We hear too often of some failure in construction, and it is the duty of the engineer to see to it that such failures do not occur. The old excuse, "error of judgment," should be discarded and the engineer should take care that the "error of judgment" is not "greed of contractor." The lack of proper supervision in concrete construction is responsible for too many of the failures, and the desire to see "how cheap" rather than "how good." The best is none too good, and with proper materials, proper construction and proper supervision, there is no reason why concrete construction should not hold the place which it has attained and continue to advance in favor and in merit. I mention supervision last, but it is the most important of all, and it is here where we engineers do have and will have an opportunity to show what we are worth. Concrete construction is one of the oldest and most stable of all forms of building, as has been proved by the remains of the old viaducts which are still to be seen in European countries.

Our own country is already launched upon one of the greatest of engineering undertakings, the construction of the Panama Canal. While this is only in its infancy, it is a very lively infant and promises well for its sponsor.

In this connection I am pleased to call the attention of the members to our speaker of the afternoon, Mr. Lewis M. Haupt, of Philadelphia, who will present a kindred subject, which, I am sure, will be interesting to all: "The Relation of the Engineer to Transportation." The address will be illustrated with lantern slides, and Mr. Haupt is very desirous that a general discussion should follow his remarks. I would, therefore, urge you all to be prepared to take part in it.

You will also, before the close of the session, have a chance to discuss a "Proposed bill to regulate the practice of Civil Engineering and Surveying in Connecticut." This is a matter that has been considered by your Board of Direction and is now presented to you. The more safeguards we can place around our property and our records the better for us, and it is with this idea in view that the matter is presented. The draft is, of course, in preliminary form, and it remains for you, in your good pleasure, to criticise or modify the same.

In closing, I can only express the hope that our Society will continue to prosper, and that it may be known both within and without the state by what it accomplishes. There are many disheartening experiences for the young engineer, as those of older experience can testify, and while all of us cannot be occupied in building a canal or a subway, there is always room for those who are willing to work, thereby accomplishing something, even though it be small, that may tend to the advancement of our chosen profession.

THE PRESIDENT: Mr. Secretary, are the tellers ready to report?

SECRETARY JACKSON: I understand, Mr. President, they are not quite ready.

haps looks more dignified to leave it out, but if such should become the case, that the advertising should fall off, we would be really in bad shape.

The balance in the treasury always appears larger as reported at this time of the year than at any other time because there is an accumulation of money, but immediately after the Society adjourns the bills begin to come in, and without that amount of balance on hand we would be unable to pay our bills promptly. The expenses of the Society then come in, and as we print this report which is about to appear, and pay the expenses of this convention, if we did not have about the amount of money that we now have on hand we would be obliged to run in debt. We could not meet our bills promptly as they come in. By having the amount of money that we take in now, we are able to meet the expenses for this meeting, and those for the summer meeting, and publish our report, and our other expenses, and we are enabled to give the members better entertainment, and to undertake matters in the way of entertaining that we could not do without it. My personal feeling, Mr. President, is against any reduction. In fact, as I feel now, I would be much more in favor of increasing our dues rather than lowering the amount.

MR. BELDEN: Mr. President, I quite agree with what Mr. Kellogg has said. It has seemed to me, also, that our Secretary-Treasurer has always received a very small compensation for his services, and if there is any change to be made in the dues, it occurred to me that an advance in his compensation would be preferable to the members of the Society rather than a reduction in the dues. There is a considerable burden upon our officers to take care of the detail work of the Society. In connection with the office of the Secretary-Treasurer, I know that that has been very considerable, and that he has done a large amount of work for which he has not been compensated by the Society. Before we consider any proposition to reduce the dues, I think we should be in a position to pay better compensation to our officers than they are receiving to-day. I quite agree with Mr. Kellogg, if there is to be any change made in the dues, I should be in favor of advancing them rather than of a reduction.

THE PRESIDENT: Anyone else anything to say on this matter?

MR. NICHOLS: Mr. President, in order to obtain an expression of the opinion of the Society, I move that the dues remain as they are at present.

Motion seconded.

THE PRESIDENT: Gentlemen, the motion is made and seconded that the dues remain as they are at present.

MR. KELLOGG: Mr. President, should that not be made perhaps, in the form of an amendment? It would not do any harm. I do not know whether I am right about it, but was any motion made before this?

MR. NICHOLS: I did not understand, Mr. President, that there was any motion in regard to the matter before the Society.

MR. KELLOGG: I am rather glad that has been made. The discussion of this subject will not do any harm even if it does not do any good.

MR. BURT: Mr. President, I made no motion in connection with this matter. My purpose was simply to draw out an expression of opinion. I do not know as I understood Mr. Kellogg's point, but as I gathered it, he meant that it would perhaps be necessary to amend the constitution.

MR. KELLOGG: Yes.

MR. BURT: I made no motion in regard to the matter. Mr. President, at all. I merely wanted to draw out an expression of opinion.

THE PRESIDENT: I do not think we want to go through the form of amending the constitution for this, because it seems as if the feeling was mostly on one side.

MR. KELLOGG: You might put that motion, Mr. President, simply as a means of ascertaining the feeling of those present.

MR. BURT: That is all, Mr. President, as I stated before, that I was trying to get.

THE PRESIDENT: I will call for the opinion of the Society. Those who are of the opinion that the dues should remain as they are at present will please manifest it by saying "aye." Those opposed. The feeling seems to be unanimous against any change in the dues.

Now as to the matter of the committee on the proposed bill, I am very sorry that Mr. Brinsmade is not here. He is chairman of that committee, and I understand is ill at home. If Mr. Crandall, who is present, can say anything about the bill, we should be glad to hear from him.

MR. CRANDALL: Mr. President, I do not know as I can say very much on this subject. The first I knew of this matter was at the meeting of the Board of Direction in New Haven last month, when it was brought up, and it seemed to be the sentiment of the Board of Direction that it would be well to appoint a committee to frame some bill so as to secure the examination and registration of the civil engineers and surveyors in the state. I was appointed on that committee, but I have been unable to meet with them. They had one meeting, I think, in Hartford, this last week, but it came at such a time that I could not get here, so that really I knew nothing more about it until I received a copy of the draft which most of us received yesterday afternoon or last evening. We did have at the meeting of the Board of Direction a rough draft, which was drawn by one of the members, but that, as I understand it, has been somewhat changed to meet the ideas of the committee. However, as regards the proposed bill as sent out, I am unable to say anything further.

MR. CORSON: Mr. President, I would like to ask as to whether this bill has been presented to the legislature as yet, or has it only been presented to this Society for discussion?

THE PRESIDENT: Perhaps Mr. Jackson can give some information about that?

SECRETARY JACKSON: I think Mr. Bush can tell you more about that than I can.

MR. BUSH: Mr. President, Mr. Brinsmade came up here last Thursday, and saw Dr. Luther in the Senate chamber. That was the last day on which new business could be introduced. It was necessary to put in the bill at that time or it could not be presented at all. As I understand it, Dr. Luther put in the original draft which is somewhat different from the bill we have printed to-day, as the committee, since then, have gone over the matter and changed some parts of the original draft. Of course, the bill can be fixed in the committee of the legislature so that it will conform to the shape that the Society would like to have it, provided that was acceptable to the committee. Mr. Brinsmade was very sorry that he could not get up here to-day. He is sick with the grippe. The doctor will not let him out. He telephoned up this morning that he would be unable to come. Mr. Brinsmade was in favor of the bill. I believe I can state that he was strongly in favor of a bill of this kind, and has taken quite an interest in it. And he considers it a good live subject, and it would do no harm to take the preliminary steps, so that if the Society wanted to go ahead with it, all they will have to do will be to appoint a committee to advocate it before the legislature, or, if it is decided here not to do anything about it, let it die in the committee. At any rate, it will certainly be a good subject for discussion.

A MEMBER: Mr. President, I have not seen the bill. Perhaps it would be well for the Secretary to read it.

THE PRESIDENT: Mr. Secretary, have you a copy of the bill? Wouldn't it be well to read it? I presume, however, that most of the members have read it because copies were sent to all.

SECRETARY JACKSON: Mr. President, I have several copies of it here, and perhaps it would be better to distribute them. The bill itself is a little long. It would take quite a few minutes to read it.

MR. BUNCE: Mr. President, I have had some talk with a good many members of the Society in relation to this matter, and I would suggest if the subject is to be discussed, that if there is any one in the room who is in favor of this bill, he should open the subject and give us the reasons for his belief in the necessity for such a bill as proposed.

THE PRESIDENT: Gentlemen, you have heard this suggestion made by Mr. Bunce. He suggests that some one in favor of the bill start the discussion.

MR. BROWN: If no one seems inclined to respond to this suggestion, would it not be well for someone who is opposed to it to speak upon it?

SECRETARY JACKSON: Mr. President, we all now have a copy of the bill, I think. I should not like to see the matter passed over without some discussion. I might say, Mr. President and gentlemen, that this matter of the registration and examination of engineers is a question that has been agitated to a greater or less extent among engineering societies, which are of considerably greater age than the Connecticut Society of Civil Engineers. In fact, it has been discussed as far back as 1884, in the state of Ohio, and particularly in the state of Pennsylvania, also in the states of Colorado and Illinois. At different times

during the existence of these engineering societies, I have noticed in their proceedings references to such a discussion. It comes up every little while in some form or another. Now I think that the matter of the registration and licensing of engineers is going to be a live subject for discussion in this Society, if not now, then in the near future. It has been pretty thoroughly thrashed out in these societies that I have spoken of, and, so far as you can learn from their reports, the majority of the members of those societies seem to be in favor of a bill of some kind, yet they have never been able to have one passed for the reason that it was opposed by some members who did not want it. About the last word on the subject was in the Ohio Society of Civil Engineers, after the form of whose bill this one was modeled. I understand that their bill received a favorable report in the committee, but what action was taken upon it in the legislature I do not know.

As to the arguments for or against it. I have seen no argument against it. I can give you briefly the arguments that I know of in favor of it. In the state of Ohio, and in a number of western states, they have what is commonly known as the county surveyor. His legal status has been to a certain limit defined in the legislative enactments of those states, but nowhere in any of those legislative enactments, or, for that matter, I might say, in any state, has an engineer any legal standing. If a physician is to be appointed at an asylum or at the state's prison, or any similar place, or if a lawyer is to be appointed on any commission, you will generally find that the law prescribes that he must be a licensed physician or a licensed lawyer, or one that has been regularly admitted to the practice of his profession, and must be one that has passed an examination, and before he has so qualified he is not eligible to the appointment. As it is now, there is no way, without a bill of this kind, for the engineer to attain such a standing. It is only recently perhaps, I might say, only within the past four or five years, that engineering has come to be regarded as a profession. We can call it so now, but before that it was not recognized as one of the old professions. As you all know, up to within a very recent time the law, medicine and theology were the only occupations that were really recognized as professions. I believe though that there was a rule or a decision some three years ago by a supreme court judge in some western state which defined the engineering craft as the fourth profession, putting it therefore upon a legal basis. Since that time literature on the subject has been more extensively written, and if you have followed it up at all, you have perhaps found that that agitation has been proceeding through different states for the betterment of the engineering profession, and the hedging around of the engineer with legal safeguards.

Now one of the greatest mistakes that has been made by most every state that has taken up this subject has been, that they have tried to impress upon the people that they were working for the betterment of the engineer and for the improvement of engineering as a profession, as a business, and for that reason, or that has been one of them, they

have failed so far to get any of the registration acts through. What we have got to do, of course, is to show the public that we are working for the public good. While we may get a considerable benefit from such a law, we have got to show the public that we are working for their interest. In other words, it has to be shown that this is a measure which tends to safeguard the public, that the engineering profession has now reached such an advanced stage, and that the duties which it is called upon to perform are so intimately connected with the proper safeguarding of the welfare of the people, that the time has come when positions involving trust and responsibility should be held by men who are qualified by education and experience to fill them; and that some men who have held these positions in the past should not be allowed to go on in the loose and careless manner they have. Of course, the state has been willing, in many instances, to accept the recommendation of the Society, either the national or state, that a man was capable. I think that the same thing is true with some of the other professions. For instance, I believe that in the appointment of a physician and surgeon in some cases, they are willing to accept the recommendation of the county society, or something like that in lieu of something else. In law, a man is required to have passed examination. In the ministry, you will find that a man has to be a licensed minister.

These, in brief, are the arguments in favor of the bill. As to the arguments against the bill, as I said before, I have heard of none. Possibly that is because that part of the subject has not been very fully gone into. If you have read the proceedings of the Engineering Society of New York City, a large and growing society, you will find there an article touching upon the status of the profession, in which the author goes quite thoroughly into the legal standing of the engineer. I think it is a fact, as is brought out in that article, that the engineer has not received the recognition that he should before the law. And there are quite a number who are coming to the opinion that his standing should be more clearly differentiated, so that the engineer may occupy the place to which, I am sure we all feel, he is properly entitled, not only by education and attainments, but in other respects, and which for a long time has been denied him.

I do not think there is anything further that I can say. As Mr. Bush has told you, this matter was brought up because it was thought it would be a very interesting topic for discussion before the Society; that having thoroughly discussed it here, then if the society saw fit to push this bill, or some other bill in a modified form, before the present sitting of the legislature, we could do so without having to lose two years' time.

MR. BELDEN: Mr. President, if it is in order, I would like to move that this matter be tabled. We have a Board of Direction, and they are amply able to decide upon the efficiency of any applicant for membership in this Society. So far as the safeguarding of the profession is concerned, that, it seems to me, is a matter that will attend to itself; this

bill is not necessary from that point of view. Therefore, if the motion is in order, I move that this matter be tabled.

Motion seconded.

THE PRESIDENT: Gentlemen, it has been moved and seconded that this matter be tabled. Are you ready for the question?

A MEMBER: Mr. President, I would like to ask if that motion is debatable.

THE PRESIDENT: No, it is not debatable. It cuts off all discussion. Those in favor of tabling the whole matter manifest it by saying "aye." Those opposed, "no." The "noes" have it, and the matter is still open for discussion. I will say that I am very glad it is because it is something which I think needs to be discussed, and it is one of the things that we have plenty of time to take up before we adjourn. I think we ought to discuss this matter thoroughly, and if that motion is made later, after all have had a chance to be heard, we can pass it if it seems best.

MR. CRAWFORD: Mr. President, I have not given this bill as careful attention as I would like, but it seems to me that section eight, which undertakes to define what a practicing civil engineer is, within the meaning of this act, opens up a field where the engineer and the architect might clash. I have some doubt how it would apply to the employment of any engineer from outside the state in the matter of contracts, where it is necessary to call in outside assistance, and whether, that being so, interstate law would not apply to it?

THE PRESIDENT: Those are just the questions we want to discuss and find out about. Section eight, as I understand it, is intended to cover points where the engineer and architect work together. So that the question has been raised, gentlemen, whether we should not get the architects to work with us. As I understand it, the architects themselves have an association, and the matter has already been talked up with some of their members.

MR. CRAWFORD: If you will look at section eight you will see that it says, "Any person who designs or makes drawings for any bridge, railroad, harbor, canal, dock, waterway, highway, sewer, waterworks, ditch, mine, tunnel, factory building, hotel, apartment house, theatre, store, grandstand, places of amusement, structures having a public or semi-public use, or work of a similar nature, or who makes specifications therefore, or directs the construction of such work as engineer." It seems to me under that definition of what should be regarded as a practicing civil engineer under the bill, it might lead to a clash with the architects, and that that is a matter which may have to be adjusted.

THE PRESIDENT: As I said before, that is one of the particular points which has been introduced, and which should be talked over. We hope that the architects will come in with us to a certain extent.

A MEMBER: In reference to that point made by Mr. Crawford, Mr. President, it seems to me that section twenty-one covers that question so far as the employment of outside help would be concerned. That section says that a man may employ assistants on any piece of civil engineering or surveying work, and, as I understand it, the man employing

such an assistant will have to be entirely responsible for such work. It does not say that he cannot employ any outside assistants. Section twenty-one seems to me to cover that.

MR. CRAWFORD: Section 21 says, "Nothing in this act shall be construed to prevent any holder of a certificate from employing assistants on any specific piece of civil engineering or surveying work, which assistants shall not be required to hold certificates, provided that they are directly under the supervision of such holder of a certificate and responsible only to him." The employing of experts to come in is surely not covered by that.

THE PRESIDENT: If there is any doubt about that, it can be easily covered. We can introduce just as many more sections as we please.

MR. WADHAMS: Mr. President, I read through this proposed bill, and I got the impression from my reading, in the light of my experience, that it is intended to cover that point. I will say that I think section 21 ought to go even further, and cover any assistants that come in and who are put in charge of the work. I think it should be made that way because they have to be an engineer and are really in charge of the work. We should have the assistants in there the same as engineers. Section 21 should go further than it does.

MR. ALDERSON: I am heartily in favor of the expression of Mr. Wadhams in reference to assistants. We often require our assistants to take charge of work, but that does not really necessitate always the services of a man that might be classified under the head of a person having a certificate. It might possibly impose a hardship upon many engineers in business if we had to retain a man that was required to show a certificate. Of course, I realize that the legislation as proposed is coming at a time when it is not too late to adopt something. If I was satisfied that the profession of engineering was going to receive proper recognition through this medium, I think the bill would be a good thing. Of course, we hope to protect ourselves in every way possible, but at the same time, I agree with what has been said, that the time is perhaps rather short to act upon a full understanding of the contents of this bill. We cannot very well do more than talk over and discuss some of the main features that ought to be understood. One thing which occurs to me is when an engineer comes from another state into Connecticut to do some responsible work for which he is qualified, just how he may do that work, unless he has a certificate, it is difficult to determine.

MR. DE PEYSTER: It is not often, Mr. President, that we have an opportunity to indulge in any discussion of this kind in this Society, but at the same time, it strikes me that this bill is a measure that savors very strongly of paternalism. It strikes me also, that the people have got about as many commissions as they need. Public sentiment against government by a commission is growing. It strikes me, moreover, that while we have a barbers' commission on the education of barbers, and a cattle commission, and various other commissions, we can get along without a civil engineers commission. I do not think that it adds anything to the dignity or standing of the civil engineering profession

in this state to have a law of that kind passed by the legislature. It strikes me that any man who is competent to become a member of this Society is able to take care of himself in either this or any other state without any assistance from or any act of the legislature. I, myself, think that it does not add to the dignity of the profession, and on general principles I should be opposed to the enactment of any such legislation. I do not think you could ever get such a bill through the legislature.

MR. ALDERSON: Mr. President, does this measure take in simply the members of this Society, or does it apply to engineers that are not members of the Society,—those that perhaps would not be a credit to the Society; and those that are practicing without proper qualifications? If it is going to put us all on a level, the good and the bad, I think that, perhaps, would be an objection. I think it would be better provided the result of it is to put the really qualified engineers in a class by themselves, would be to add to the dignity of the profession, and in that view of it, it would be a good thing to have such a bill as this go through.

MR. HENDERSON: Mr. President, we may, possibly, want a bill to help dignify the engineering profession, and I want to say this in answer to Mr. Wadhams, that it has been my opinion, or not exactly my opinion, but my observation, that if a person has work to do of an engineering character, and employs what you might call a shyster engineer, it is his lookout. Sooner or later his work will tell. That, however, does not hurt the professional engineer at all.

Now another point; and I think that this is the strongest objection to it: if an engineer was merely a local man, and the work that he did was all of a local character, or all of his work was local in the sense of being in Connecticut, it would be all right, but many engineers here do not do all their work in Connecticut. They go to New York, to Massachusetts, to Rhode Island, and to even other states farther away. Now then, suppose those other states get a bill like ours, which aims simply to cut out the Connecticut engineers. You can readily see that in such a case it might do more harm than good. Such things have been known. The effect of it would be then simply to keep Connecticut engineers working in Connecticut. They could not go outside for business, because they would be trespassing on another man's territory without any legal right to do it whatever. In that view of it, I think it is a one-sided affair. It is something like the dog in the manger—an attempt to keep the other fellow out. If we intend doing that, it will not be long before the other fellow will attempt to do the same thing. There are too many engineers to-day working in Connecticut. There is not enough business in the local market to keep them all busy, and give them all a good living. They have got to go outside the state to get a living.

MR. BUNCE: In a comparative situation I think I can see the reason, or one reason, at any rate, why these western states that Mr. Jackson has quoted have attempted to pass such a bill as this. Out there engi-

neers and surveyors have been classified together to a large extent, while as a body, they are rather surveyors than engineers in the full acceptance of the term. They are very largely self-educated men, and men who have picked up a smattering of engineering, and are attempting to practice as engineers with a limited knowledge of the technical side of the profession, and in order that it may be properly recognized by the public they have sought to have such a law passed. Here, I think, the situation is somewhat different. I think it is a fact, as against that situation out there, that here, very largely, in this state, the engineers are educated men, men who have been trained in some scientific school or college. And I find, if I interpret article nine correctly, that the issuing of certificates by the commission to be appointed under this bill, is really an effort to divide the two classes as far as those men are concerned. If you will notice section nine, it says, "The board shall issue a certificate entitling the holder to practice civil engineering to any applicant holding lawfully a diploma showing completion of a course in engineering in any college, university, or school, whose curriculum is approved by the board, together with satisfactory evidence that he has had two years' practical experience under one or more competent surveyors or civil engineers." In other words, the graduate of a scientific school, and one having had two years' practice, this board is compelled to give a certificate to. It seems to me that that would lead to trouble. It rather gives it the look that it is a question of money. The board practically says, although you have gotten one diploma from the school now, that you are a graduate from, you give us five dollars more and we will tell you that you are a little more of an engineer, perhaps, than you think you are, if you don't pay.

THE PRESIDENT: We are glad to hear both sides of the story.

MR. HILL: Mr. President, every effect must have a cause, but I cannot understand the cause for this bill. The only reason that I can see for it is to protect the "Dear public," and to protect the employers of engineers and surveyors from being imposed upon. But I think the men who employ engineers and surveyors can be relied upon to use ordinary common sense and ordinary discretion, and are competent to protect themselves without the aid of any bill such as this. So far as this bill, which is now before the present legislature, is concerned, it seems to me that this is something of an adversary nature, that it should have been advertised before the session opened. If that is the case, it could not be legally heard. I do not think there is the least shadow of a chance of getting it through. I am opposed to the bill. I do not know that any motion has been made, but in order that there may be something to speak to, I will move that the President be instructed to withdraw the bill.

MR. BUNCE: Second the motion.

THE PRESIDENT: Gentlemen, it is moved and seconded that the bill presented to the legislature be withdrawn. Are you ready for the question?

MR. BURT: Before that motion is put, Mr. President, I would just like to call attention to the fact that the suggestion of the Secretary, that it be allowed to die a natural death in the committee, perhaps, would be all sufficient.

THE PRESIDENT: As I understand, the bill has to go before a committee of the legislature, and then a hearing is had. This has not yet been announced, and I do not think that it has gone that far. Perhaps, as Mr. Burt says, it is not necessary to even withdraw it, but simply let it alone. I will put the motion, however.

MR. BUNCE: Mr. President, allow me to make a suggestion in that connection. That bill has gone in. Now suppose there is no action taken by this Society. If the Society is opposed to the bill, what is to prevent my friend Jackson and one or two others who are interested in the bill, from going up before the legislative committee and so filling their minds with the necessity of it, that before we know anything about it, the committee report in favor, and the thing should go through. Now the Society is opposed to it, and I think we should voice that opinion, and have it our official action, and not allow the matter merely to lie there in the committee to take its chances of being killed, because it is a poor bill.

SECRETARY JACKSON: Mr. Bunce has referred to me, Mr. President, as one of those who are among the few friends of the bill, and has suggested that I may go up before the committee and fill their ears with arguments in favor of it, and I thought perhaps you might be willing to listen to a few more remarks from me. What I said was, that nobody had any intention of pushing this bill without the approval of the Society. If they had, they would not have submitted it to you for your approval or disapproval. It was the opinion of the Board of Direction that as this was a matter of importance to the engineering profession, it should be taken up and discussed here. As I told you before, it is a matter which has been discussed by other engineering societies throughout the country in such meetings as this Society has been having, and is having to-day, and it has been the idea all along that a little good-natured discussion, which would leave no bitterness behind it, and in which the feeling or motive of the Board of Direction, or the framers of this bill, would not be questioned, would be a good thing for everybody. Now, as a matter of fact, the bill, as I understand it, will be pigeon-holed if there is no action taken by the Society, but I think that the Society ought to take some positive action. The bill has been presented by the members of the Board of Direction in good faith, thinking that they were doing something for the benefit of the Society, and for the betterment and improvement of your knowledge of engineering affairs, and, as it stands, I think that they, at least, are entitled to courtesy, and that you should either instruct them to go ahead with the work, or possibly you might thank them for what they have done, and then instruct them to drop it if you wish. As to their going ahead without your consent, there is no fear of that.

MR. BURT: It seems to me that this discussion, though in fact I have hardly given the matter sufficient attention, yet the discussion is one which has convinced me that there are some very admirable features in this bill. I am not ready to say that I would not be in favor of it. I think our Secretary has presented some very strong reasons why such a bill should be passed, and the facts which have been brought out that the great professions like the law, and medicine, have to attain a certain standing, and have to have a certain legal status before they can practice, in my opinion, renders such professions of greater dignity, and I can readily see how they would benefit from such state action. We, on the other hand, lose a great deal, I am convinced, from our present situation as a profession.

In reference to what Mr. Bunce said as to college graduates, or members of societies which are advanced in the profession, that under this bill it would simply be a demand to pay five dollars for an examination,—let me say that I think that is proper. A party that has not passed a thorough examination to get his certificate could very well afford to pay twenty-five dollars. An examination certainly will not hurt any competent man. I think it is proper.

I think there are some admirable features in this proposed bill, and I am not ready to vote against it.

MR. NICHOLS: Mr. President, I do not say that I am either opposed to or in favor of the bill, but I think instead of putting it to vote and having it declared that we are not in favor of the bill, the time ought to be devoted to a thorough discussion of its details. More than that, we ought to hear the reasons for it. So far, I have not heard very much said of the necessity for any such bill. I hope there will be further discussion.

I would like to ask one question in regard to the bill, and that is, what particular benefit is it going to be to us as engineers? And whether it gives any more protection in suits for damage than we have at present.

THE PRESIDENT: Mr. Secretary, could you answer that question?

SECRETARY JACKSON: I do not know as it would. I do not know very much about the bill further than, as I say, it is framed on about what the other societies have been working on, and the conclusions they have reached. I expected to get quite a little information from the continuance of the discussion, and it is just such little points as that that we ought to be informed upon. I do not think it would have any particular effect in the case Mr. Nichols has brought up. In fact, we do not know how a bill of this kind would work in practice. It is experimental. We have no precedent to go by, and we do not know just what it would do. There are probably a lot of errors in this bill, and it may be that it might not be best to have it passed at this time, but in taking the matter up you are in line with the thought of a number of engineers in other states. While it may not be best to take action this year, or possibly not next year, or the year after, I think before very many years have gone by, you will see that some such form of legislation as this will be enacted by a majority of the states; you are simply

plowing the ground at this time, and getting yourselves in such a position that you can intelligently discuss the matter, and I am sure it will not be long before we will all feel that in taking it up we have been doing a little good.

MR. KELLOGG: Just to help Mr. Jackson, I want to say that this matter is purely tentative. It has been brought up simply to give an opportunity for discussion. He has put a whole lot of work into the present bill.

MR. CRANDALL: I feel, being a member of the Board of Direction, and also a member of this committee, which is supposed to be taken to be the father of this bill, that I ought to take a little exception to some of the remarks that Mr. Jackson has made. I think it was stated that the Board of Direction had thought best to bring this matter up at this time and to have it presented to the legislature, and that the Society should either approve or disapprove of what has been done. At the meeting of the Board of Direction this matter was brought up. I, for one, had never heard of the matter being discussed before, but in talking it over that day we decided that the Board of Direction ought not to go ahead with anything in the matter, but that it would be perfectly proper for us to appoint a committee to work on the bill, and that the bill be presented to the Society for discussion. I must say that I was very much surprised this morning when I found that the bill had gone into the legislature. That was a matter that I brought up at the time of the meeting,—that I did not think we ought to go ahead with anything of the kind in the name of the Society until the Society had amply discussed it, and my understanding of the matter at that time was that this would be brought up at this meeting, and the Society given ample time, not in one meeting alone, but several if necessary, to discuss this before it was brought up for passage. So when Mr. Jackson says that the Board of Direction has taken it before the legislature, it seems as though it was hardly correct, because it was not my understanding that the Board of Direction would do that. That was not the understanding that I had when I was present at the meeting. Of course, as I said before, I was not present at the one and only meeting that this committee has had, though, of course, the majority of the committee may have been there. I was very much surprised that anything of the kind had been done.

MR. BELDEN: Was the committee authorized by the Board of Direction to have such a matter as this put before the legislature—such a bill? Was that done by the Board of Direction? By whose authority was this bill put in the hands of the legislative committee before which it is pending?

THE PRESIDENT: I would say that the Board of Direction left it entirely in the hands of the committee.

SECRETARY JACKSON: Yes, it was left in the hands of the committee. As Mr. Crandall says, the Board of Direction authorized this bill printed, etc. Of course, Mr. Crandall should be more familiar with it than I, being a member of the committee. I was not sure whether the bill had gone before the committee or not. As I understand it, the reason the

bill was put in was that the last day had arrived upon which new business of this kind could be presented to the legislature, and if the bill was to be presented at all, it would have to be then. It could do no harm if the Society should instruct the committee to go ahead; they could then do so without having to wait two years. On the other hand, if it was not the desire of the Society that anything should be done, it was not expected there would be any trouble in dropping it. It was left with the committee with power to act. I do not think that there is anything for anybody to get alarmed about. The bill is up there, and if there is nothing done it will be pigeon-holed. There are a hundred other bills up there that will meet with the same fate. As for being alarmed over it, I do not think there is any reason for it whatever.

MR. FORD: I am sorry that I am not as well read on this particular subject as Mr. Jackson is. I have not read it carefully at all, but I would like to have the Society express to Mr. Jackson and others, its appreciation for the large amount of work that they have put in in drawing up this proposed bill, as a slight recognition for their services. Even if nothing is done in favor of pushing the bill, it seems to me that this discussion has been well worth while.

One of the arguments of Mr. Jackson is a very strong reason against its passage. He says that several of the states have had these bills under discussion for several years, but, if I understand him correctly, there has been no bill passed by any of these states. Apparently, they have been talking about it for twenty years or so, but they have no such bill in operation. I think that is a pointer for us; it affords a basis upon which the Connecticut Society should act. I would not care to be a member of the pioneer society in a matter of so much importance. I think it is well to discuss it, but before we adopt it, I think it would be equally well to wait and see how it works in some of these other places where they have discussed it much more than we have. The state of Massachusetts is one of the most progressive states in the Union. There are no more commissions in any state in America, or in any other country, in my opinion, than there are for various purposes in the state of Massachusetts. They seem to be in the habit up there of trying every new thing that comes along. I think it would be eminently safe for this Society to wait a little while until some other state like Massachusetts or Ohio, as Mr. Jackson says, passes one of these bills. Let us wait and see how it operates. If I understand, the main object of this bill is not only to protect the engineer, but to protect the client of the engineer. Every man in this business knows that if he is hired by a client, and does not satisfy his client, he will soon be driving an express wagon, or working with a pick and shovel, or at something besides engineering. I think that every man here knows that whether we have any such law or not, if he is to maintain his place in the profession, he must satisfy his client, and I think that every man in this room is able to take care of himself. It seems to me that this proposed bill will protect the other fellow, and we are not getting anything in return. As has well been stated by Mr. De Peyster, I can go into a barber shop and I see a

card hanging up on the wall to the effect that the barber has passed an examination, but if I am not satisfied with the shave I get I am going to go somewhere else. I am going to get a shave where the proprietors keep everything clean and sweet, and do their work in good shape, no matter whether they have passed an examination and have a card or not.

It is just so with our profession. It is for our own interest to give our clients satisfactory service. When I die I do not expect to be given any better burial simply because we have an embalmers' commission at the state capitol. My friends and the undertakers will take care of that. If I have enough money to give me a first-class burial, my friends will take care of me. The purpose of the bills creating all of these commissions is simply to protect the public, but we know that we have to protect those who patronize us, and have to give our customers satisfaction or we are not going to get business.

It does not make any difference whether we have a bill of this kind or not, so far as that is concerned. I think that this Society, therefore, can afford to go slow with this bill. So far as I am concerned, I shall vote against it. I am in favor of Mr. Hill's motion, instructing the legislative committee, if we have one, to withdraw that bill in the name of the Connecticut Society of Civil Engineers.

THE PRESIDENT: It has been moved and seconded that the bill as presented be withdrawn.

MR. BUSH: Mr. President, I think we are doing Mr. Brinsmade a discourtesy in assuming that he has put the bill in through Dr. Luther, in the name of the Society. Mr. Brinsmade did no such thing. We can pass a resolution that it is the sense of this meeting, or the opinion of the Connecticut Society of Civil Engineers that the bill should not pass, but I do not think that we ought to instruct anybody to withdraw a bill that the Society has not put in. If I understand that motion correctly, it orders the Society to withdraw the bill. I do not know that the Society has any bill up there, or that we have any power to give anybody orders to withdraw it. I am not sure that we can withdraw it.

MR. HENDERSON: That leaves the bill in one man's hands. If he sees fit to pass it, he can do so. All he has to do is simply to go up to the capitol and lobby it through. No question about that. I think the Connecticut Society ought to have something to say about it. The bill was certainly sent out for discussion, and for action, and I think whoever put it before the legislature should be governed by the feeling of the Society in regard to it.

SECRETARY JACKSON: I would say, Mr. President, in the way of a suggestion, why not record the vote of the Society as adverse to any bill of this kind. It would have the same effect. Putting the Society on record as being adverse to the bill would be enough. I am not making this as an amendment, but merely a suggestion along that line. If Mr. Hill would amend his motion to the effect that the Society is adverse to a bill of this kind, it seems to me that would do.

MR. FORD: Mr. President, I would like to ask if Mr. Brinsmade had any authority for introducing the bill? If any vote was passed by the Board of Direction authorizing or requesting him to introduce the bill?

SECRETARY JACKSON: The committee that was appointed was given full power. The bill was left with them with full authority to act; to do as they saw fit in the matter.

MR. BUSH: Mr. Brinsmade did not introduce the bill for the Society. He took the matter up by correspondence, and after talking with Dr. Luther, introduced the bill because he was in favor of legislation of some such character, but Mr. Brinsmade did not represent the Society in any official capacity by so doing. He was not instructed by the Board of Direction to introduce such a bill. The bill is not introduced as a bill of the Connecticut Society of Civil Engineers. I think the motion that Mr. Hill has made is wrong. It ought to be changed in some way so it does not put Mr. Brinsmade in the position of introducing something without the backing of the Society. He did not do that.

MR. BURT: I am entirely in sympathy with what Mr. Bush says in the matter. I think it would be a discourtesy to Mr. Brinsmade. If that idea, that this Society is adverse to the passage of such a bill at the present time, was put in the way of an amendment, I should be in favor of it.

THE PRESIDENT: Is there any amendment offered?

If Mr. Brinsmade did not introduce this bill on the part of the Society, or acting in behalf of the Society, I do not see how the Society can have the bill withdrawn. If it was not introduced by the instructions of the Society, how can the Society instruct any member or committee to have it withdrawn?

A MEMBER: I do not believe, Mr. President, that it can be withdrawn. Would it not be in line to amend the motion and instruct some officer of the Society to appear against the bill when the bill comes up for a hearing?

MR. DE PEYSTER: Mr. President, if Mr. Hill will put his motion in this way, that it is the sense of the Society that it is not in favor of the bill, and that it is the sense or opinion of the Society that the bill should be withdrawn, and the second would allow that change in the motion, I think that would go all right, and cover the ground that Mr. Hill wants to be covered.

MR. HILL: I will accept that amendment. I did not intend any discourtesy to Mr. Brinsmade or anybody else, and it hardly seems as if what I said could be taken in that sense. I certainly would not intend anything of the kind with reference to Mr. Brinsmade, as he is a personal friend of mine. My impression was that the bill had been sent to the legislature and was before a committee. It seemed to me that unless this Society wished to go on record as favoring it, that they should have it withdrawn in some way, or at least make it known to the committee that the Society did not wish it passed. I will accept the amendment of the gentleman, that it is the sense of this meeting that the Society is opposed to the bill and wishes to have it withdrawn.

MR. CONSON: That ought to be carried. I am heartily in favor of the idea of making it known that the sentiment of the Society is not in favor of this bill, and I think that a memorandum or record of this sentiment ought to be placed in writing or personally before the senator and the committee having this matter in charge.

THE PRESIDENT: How will you make the amendment to the original motion as it stands? That the bill be withdrawn?

A MEMBER: The only thing I am afraid of, Mr. President, is that even though we are opposed to this bill, that we cannot withdraw it. I presume legally we cannot withdraw it, but we can, at least, have an expression of our views brought in some way before the committee, so that they will see that we do not endorse it, and are opposed to it.

MR. PALMER: How would it do to have Mr. Hill's amendment or his motion amended in this way: that the officers of this Society be instructed to appear at the legislature and oppose the bill that is offered?

THE PRESIDENT: I should hardly think that that would be necessary. It has not got quite as far as that.

A MEMBER: The bill having been introduced, I think all you can do with it to prevent its passage is to have it rejected.

MR. BURT: I think it would be better, and would create a better feeling all around if it could be withdrawn. I think you can arrange so that the bill can be withdrawn.

THE PRESIDENT: There is still only one motion before you which can be amended.

MR. DE PEYSTER: What objection is there, Mr. President, to passing that motion, if we can, and then let somebody put another motion, allowing the officers to put in writing the objections that the Society have to the bill as introduced, and asking permission to withdraw it?

THE PRESIDENT: That may do, if that is the sense of the meeting. I will put the motion as it stands. The motion as made is that the bill be withdrawn, as it is against the opinion of the Society at this time to have it passed. I will put this motion, and then another can be acted upon.

MR. KELLING: I object to that, Mr. President. I do not understand that that was the way the matter stood.

MR. HILL: I accepted the amendment which qualified the original motion.

MR. DE PEYSTER: I did not offer an amendment. I suggested that Mr. Hill make his motion in this way: that the Society is opposed to the passage of that bill, and that it is the sense of the Society that the bill should be withdrawn. That is the way I put it. Mr. Hill accepted that, as I understood it, and made it his own motion, and that is the motion that is before the house, and Mr. Hill asks you to put the motion in that way, as I understand it.

THE PRESIDENT: I think that makes it clear: that Mr. Hill accepts the motion as stated by Mr. De Peyster. That motion has been seconded. As many as are in favor of the motion as stated by Mr. De Peyster manifest it by saying "aye." Contrary minds, "no." It is a unanimous vote.

Now, is there any further miscellaneous business?

MR. BUNCE: Before you announce the report of the tellers on the election of officers for the next year, I desire to offer a motion, and it is in recognition of the very valuable and arduous services of our Secretary-Treasurer, not only in the preparation of this bill, but in the other work, involving a great deal of detail and minutiae, which he is called upon to perform during the year, and in order that it may come strictly within the legal element of not raising a man's salary after he is elected, I move you, sir, now, that the salary of the Secretary-Treasurer of this Society be fixed at \$150.00 a year.

A MEMBER: Mr. President, I heartily second that motion.

THE PRESIDENT: Gentlemen, you hear the motion of Mr. Bunce. Are there any remarks? It is moved and seconded that the salary of the Secretary-Treasurer of this Society be \$150.00 a year, beginning with the next year. Are you ready for the question? As many as are in favor of this motion will say "aye." Contrary minds, "no." It is carried unanimously.

If there is no miscellaneous business, I think the tellers are ready to report. Mr. Olmsted, have you the report of the tellers?

Mr. Olmsted then read the following announcement of the vote:

Whole number of votes cast	102
Of which, for President, Mr. D. S. Brinsmade has	102
For First Vice President, Mr. Edward W. Bush	
has	101
For Second Vice President, Mr. Frederick J.	
Easterbrook has	61
and Mr. Francis H. Oldershaw	22
the whole number of votes cast for First and Second	
being	83
For Secretary-Treasurer, 100 votes cast, two blank,	
of which J. Frederick Jackson has	100

The choice for members of the Board of Direction is as follows:

Henry J. Kellogg	49
Charles F. Chase	36
Paul Nash	7

In your choice for members of the Board of Direction, there were a large number of ballots on which there were four members voted for, so that the ballots had to be thrown out. There were thirty-nine rejected for that reason, so it would be well to have in mind not to vote for more than two members on that board.

THE PRESIDENT: Gentlemen, you have heard the report of the tellers. I would state that the constitution provides that a plurality of votes shall elect. I would, therefore, declare that Mr. D. S. Brinsmade has been elected President, Mr. E. W. Bush, First Vice President; Mr. F. J. Easterbrook, Second Vice President; Mr. J. Frederick Jackson,

Secretary-Treasurer, and Mr. Henry J. Kellogg and Charles F. Chase members of the Board of Direction.

MR. KELLOGG: Mr. President, I move that the Secretary be instructed to send a telegram to Mr. Brinsmade, informing him of his election.

Motion seconded.

THE PRESIDENT: Gentlemen, it is moved and seconded that the Secretary be instructed to send a telegram to Mr. Brinsmade, informing him of his election. All those in favor will say "aye." Contrary minds, "no." The motion is passed.

I would say that this program announces an address of welcome by Mayor Henney, but owing to other engagements which the Mayor was obliged to attend, he could not be here this morning. He has promised to be with us at our lunch, however, and also, it is hoped, will be with us this evening, that is, for at least a part of the time. I understand that he has two other dinner engagements before he gets to us, but we will try to give him something in the way of a third one. Mr. Clark is distributing the tickets for the lunch, and we expect that all of the men who are here will sit down with us. If there is no further business a motion to adjourn is in order.

MR. KELLOGG: I move that we adjourn until the time stated on our program for our afternoon session.

Motion seconded and passed, and the meeting declared adjourned until 3 P. M.

AFTERNOON SESSION.

The convention was called to order at 3 P. M., President Charles F. Chase in the chair.

THE PRESIDENT: Gentlemen, it gives me great pleasure to introduce to you the speaker of the afternoon, Mr. Lewis M. Haupt, Consulting Engineer, of Philadelphia, Pennsylvania, who will address you on "Epochs of Transportation."

Mr. Haupt's paper is printed on page 111.

Discussion will be found on page 127.

THE PRESIDENT: Now, gentlemen, if you have any questions to ask, I am sure Mr. Haupt will be very glad to answer them.

THE PRESIDENT: If there are no further remarks, you have heard Mr. Kellogg's motion, that this matter be taken up to-morrow morning. I believe the motion was seconded. Are you ready for the question?

All in favor say "aye." Contrary minded, "no." It is a vote.

I am sure we are all very grateful to Mr. Haupt for this very interesting talk. It is a good subject, and ought to interest every engineer in the state.

SECRETARY JACKSON: I think it is proper that the society extend a vote of thanks to Mr. Haupt to show that we have all been interested and enjoyed it very much, and I move you that the society extend to Mr. Haupt a vote of thanks for his kindness in coming before us this afternoon.

Motion seconded and carried.

MR. HAUPT: Gentlemen, I am very much obliged to you.

THE PRESIDENT: We have one more paper down on the program for this afternoon, by Mr. John F. Trumbull, who will give us his paper on "The New Haven Cut."

Mr. Trumbull's paper is printed on page 62.

Discussion will be found on page 128.

MR. KELLOGG: I move that we adjourn until the time specified tomorrow morning.

SECRETARY JACKSON: Mr. President, before we adjourn, I move that a vote of thanks be extended to Mr. Trumbull for his kindness in giving us this paper.

Motion seconded and carried.

THE PRESIDENT: There is a motion to adjourn. Is it seconded?

Motion seconded.

THE PRESIDENT: Motion is carried and the meeting stands adjourned until to-morrow morning at nine o'clock.

MORNING SESSION—WEDNESDAY.

Convention called to order at 9.20 A. M., President Charles F. Chase in the chair.

THE PRESIDENT: Gentlemen, come to order, please, for our morning session. At the end of our meeting yesterday afternoon a matter in connection with Mr. Haupt's paper was put over until to-day. I should say that the present would be the time to take it up, and dispose of it in one way or another. A motion concerning it is in order.

MR. KELLOGG: Mr. President, I move you, that the President appoint a committee of three to whom this matter shall be referred for future action. I do not think we are prepared now to proceed to a discussion, except a discussion under this motion, or to take the matter up in detail.

MR. BUNCE: Mr. President, I would like to inquire of Mr. Kellogg just what he means by that motion. I wish he would state a little more fully just what the purport of this resolution is. I did not quite gather it. I did not carry it in my mind from yesterday. I would like a little further information about it before the motion is put to a vote.

THE PRESIDENT: Will Mr. Kellogg speak a little more in regard to the exact matter?

MR. KELLOGG: I know very little about it, Mr. President. Before I made the remarks that I did yesterday afternoon, I had had an opportunity to glance over a typewritten copy, and the purport of it, as I gathered it, was that a resolution or something on the line of what is contained in this paper should be passed. I can read this if you like, Mr. President.

THE PRESIDENT: If you please. I think it would be a good thing to read it for the information of the members.

MR. KELLOGG reads:—

Whereas, the growth of traffic in the United States has far exceeded that of the population, and of the railroad mileage, and has resulted in congestion, waste and great suffering and delays to the citizens;

And whereas, the attempt on the part of the railroads to carry raw materials and fuel to provide for the rapidly growing industries of the country has overtaxed their capacity and resulted in the engorgement and restraint of manufactures with additional cost for distribution;

Whereas, the waterways have not kept pace with the demands of commerce and cannot do so when dependent upon national appropriation, from the public treasury and the approval of plans and supervision from a central authority covering the entire national domain and the insular possessions;

Whereas, the policy of local initiative and control is recognized as best for the building up of the domestic commerce of all systems of transportation, waterways, as well as the common roads and railways, as being the quickest, most economical and safest;

Whereas, great delays are inevitable in securing legislation from the government where there are so many conflicting interests securing appropriations, thus restraining the development of the cheapest modes of communication for generations;

It is therefore resolved:

That the antebellum policy of encouraging states, municipalities, corporations, or private parties to make improvements at their own cost and risk, for the purpose of relieving their localities and providing relief where there are opportunities for commercial development, should be encouraged by the passage of general legislation restoring these rights to the states and other parties with the right to charge tolls on tonnage thus created for a limited term of years."

All the opportunity I had yesterday afternoon was to read that over and then get up and say something on the spur of the moment, which I did at that time. I consider it rather complimentary to Mr. Haupt to take notice of the suggestions which he has offered in this way. I think I can say that you would hardly want now to start in and discuss this matter, without having given it any thought. I feel that way myself. I do not know how it is with the others. It is the first time I have ever thought of any such thing, or ever heard of such a thing. There are only a few of us around here that keep any track of such things. There has not been much in this state to call our attention to such a matter as that. We have not, in this state, any canals that amount to anything, and no particular reason that I can see for building any. Other states, however, are a good deal worse off in that respect than Connecticut. It is well enough, however, to have this subject for discussion later, and it is perhaps better to have the matter put in form for us by a committee. I think it is a matter that should be referred to a committee, and let them give it some thought, and make a report. I think it would be a good subject for us to discuss at some other meeting. Such a discussion will be instructive and educational, and it would be a good thing to have it considered.

MR. BUNCE: The reason that I asked Mr. Kellogg to make a little fuller statement of the subject was to see how far the matter went. Personally, I see no objection whatever to it. If it went further than it

does, I had something to say in the matter, but I have no objection, personally, to it as put forth in that paper.

MR. HILL: This may prove to be a matter of considerable importance. At any rate, it is a matter that requires considerable attention, but to have a special committee appointed, study it out and then make a report to the society, it seems to me would take longer than necessary. I would like to make an amendment to Brother Kellogg's motion, that the whole matter be referred to the Board of Direction with power to act. They can consider the matter and take such action as they think is necessary.

MR. BUNCE: I will second that amendment.

THE PRESIDENT: Gentlemen, Mr. Hill presents an amendment that the whole matter be referred to the Board of Direction. Are there any remarks upon the amendment?

MR. KELLOGG: Mr. President, I am willing to accept that amendment. I think that the Board of Direction can act as a committee. It does not make any difference whether it is referred to a committee or referred to the Board of Direction. I will accept Mr. Hill's amendment.

THE PRESIDENT: Gentlemen, Mr. Kellogg accepts Mr. Hill's amendment. Are you ready for the question? The motion is that the whole matter be referred to the Board of Direction with power to act. As many as are in favor of this will say "aye." Contrary minded, "no." The motion is carried. It is hardly necessary to put the original motion as the acceptance of Mr. Hill's amendment made one motion of it.

I think that is all the unfinished business that we have, and we come now to the papers. Gentlemen, the first is "The Charter Oak Sewer System, Method of Assessment," by A. B. Alderson, Town Engineer of West Hartford.

Mr. Alderson's paper is printed on page 1.

Discussion will be found on page 131.

THE PRESIDENT: Gentlemen, have you any further discussion of Mr. Alderson's paper? If not, we will pass on to the next one, entitled "Description of Concrete Curb on Park Terrace, Hartford, Conn.," by Herbert G. Clark.

Mr. Clark's paper is printed on page 7.

Discussion will be found on page 139.

THE PRESIDENT: Gentlemen, the next paper on the program is one by Mr. C. E. Chandler on "Some Engineering Features of the Norwich Hospital for the Insane." I think Mr. Chandler has not arrived as yet, so we will pass on to "Transverse Contours for Roadway Pavements," by Mr. H. H. Gladding.

I am sorry to say Mr. Gladding is sick, and unable to be with us, but if anyone has any questions to ask in regard to his paper, we should be glad to have them brought up.

MR. BROWN: Mr. President, I do not know that I can ask any intelligent questions on the matter, or bring out anything of advantage to the members in the absence of Mr. Gladding, but I might say that I am very much interested in the matters presented by Mr. Gladding, who

seems to have arrived at a very good conclusion for a roadway, and worked out tables for figuring the street parts and putting them in. The question might be asked in regard to the proper amount, that is, that the curve should be tipped at the gutter, whether it should be more on the longitudinal grade than on the level street. If he was here I would like to bring up some of those things.

THE PRESIDENT: That would undoubtedly be a very interesting point to discuss. If anyone can answer the question that has been proposed we will be glad to hear it. If not, we will go on to the next paper, which is a paper on "The Completion and Operation of the New Haven Water Company's Filter Plant," by Charles A. Ferry, of New Haven.

Mr. Ferry's paper is printed on page 29.

Discussion will be found on page 143.

THE PRESIDENT: Are there any further questions or discussion upon Mr. Ferry's paper?

Is Professor Tracy here?

MR. FARNAM: Mr. President, Professor Tracy is unable to be present, and he has asked me to read certain parts of his paper.

THE PRESIDENT: Mr. Farnam will read parts of Professor Tracy's paper.

MR. FARNAM: I regret very much that Professor Tracy is not here this morning, because he has given considerable attention to this subject of errors in sighting and has spent a great deal of time in planning experiments, in reducing his data to results, and formulating his conclusions. You will notice at the bottom of page 38 that Professor Tracy is getting this data and material together to be used in a textbook, which he intends to publish. Of course, in that the results will be published in the manner in which they were obtained.

I will not read all of the paper, especially the figures, but will read certain parts of it as I think will develop the points which Professor Tracy desires to bring out.

Prof. Tracy's paper is printed on page 38.

Discussion will be found on page 145.

THE PRESIDENT: Is there any further discussion?

SECRETARY JACKSON: Mr. President, if there is no further discussion on Professor Tracy's paper, there is a little matter here that I would like to take up.

THE PRESIDENT: Mr. Jackson says that he has something to mention at this time.

SECRETARY JACKSON: Mr. President, I suggest that as it is apparent that the session will be prolonged into the afternoon, that after the next paper we take a recess of thirty minutes, and then come back and finish up the remaining papers. I will put that in the form of a motion, although I think it is hardly necessary.

I have had this communication laid upon the table. It is a request by one of the members of the society, through the President, for the appointment of a committee to prepare a paper for discussion at some future meeting, the paper to be upon the following subject, "The Obl-

gation of the Engineer to the Contractor, Taken in Connection with His Obligation to His Employer, not only as regards the drawing up of contracts, but also as regards the equitable interpretation of the same." This is something which can probably be taken up at this time and disposed of. In order to expedite matters, I move you, Mr. President, that a committee of three be appointed to carry out this recommendation.

MR. CRAWFORD: I would suggest, Mr. President, that Mr. Chase be a member of that committee, provided the motion goes through.

THE PRESIDENT: Is the motion seconded?

Motion seconded.

THE PRESIDENT: The motion is made and seconded that a committee of three be appointed. How is that committee to be appointed, from the floor or by the Chair?

SECRETARY JACKSON: It could not very well be appointed by the Chair if the President is to be a member. I guess it better be appointed from the floor. I will include that in the motion.

Motion carried.

SECRETARY JACKSON: Mr. President, I move you that Mr. Chase be one member of that committee.

Motion seconded and carried.

MR. BURT: I would nominate Mr. Charles A. Ferry as another member of that committee.

Motion seconded and carried.

MR. HENDERSON: Mr. President, I nominate Mr. Ford, the city engineer of Hartford.

MR. FORD: I would prefer not to serve on that committee. I would prefer to have some engineer who has had more direct experience with the subject than I have. I would like to offer in my place Mr. A. B. Hill, of New Haven, who has had a great many years' experience in all kinds of work, and I think if he is willing to serve it would be a great advantage to the society.

MR. HILL: I especially ask to be excused. I think one member from one office is enough. You have Mr. Ferry from our office.

THE PRESIDENT: I think that Mr. Hill's point is well taken, although I have no doubt that Mr. Ford regrets that Mr. Hill is perhaps disqualified for the reason given.

MR. BURT: I would nominate Mr. Charles H. Bunce.

Motion seconded and carried.

SECRETARY JACKSON: There is another paper, Mr. President, I believe, to take up before we adjourn.

THE PRESIDENT: We had yesterday afternoon a paper on the New Haven cut work. We will now have a paper on the "Highway Bridges of the New Haven Improvement," by Mr. C. L. Slocum.

Mr. Slocum's paper is printed on page 46.

Discussion will be found on page 146.

THE PRESIDENT: Is there any further discussion of this question?

MR. NICHOLS: If there is time this afternoon for the discussion, and it is the will of the society that it should be taken up, I would like to

bring up for discussion the advisability of the civil engineers establishing a schedule, or fixed minimum charges. I would like to bring this up this afternoon if there is time.

MR. KELLOGG: Before we take a recess I would like to make a motion that we give a vote of thanks to the Committee on Arrangements which has conducted affairs here. I would like to make an unparliamentary use of making a motion just to say that the committee has, in my opinion, and I guess in the opinion of all present, done admirably. What the members have done is particularly appreciated by the New Haven men. I know at the Garde one of the men at the table where I was sitting spoke up and said, "Kellogg, these Hartford men have got us New Haven men cleaned out. They are 'way ahead of us." We thought we had done very well before when you have been in New Haven, but take it right through, and I must say that you have done better than we have in New Haven. I would particularly like to speak of one little thing. I think that the orchestra that they furnished us last night was unique, and it was certainly very delightful.

MR. HILL: Mr. President, I hope I may be allowed to second the motion of Mr. Kellogg. I am sure we all appreciate very much the courtesies of the Hartford and New Britain people which have been tendered to us. When you came to New Haven we tried to treat the boys as well as we could, but I think the Hartford and New Britain men must have taken the cue from our experience because they have certainly gone us one better. I would like to second Mr. Kellogg's motion of thanks for courtesies tendered.

THE PRESIDENT: Gentlemen, you hear the motion which has been made by Mr. Kellogg and seconded by Mr. Hill, that a vote of thanks be extended to the Hartford and New Britain members of the society who have prepared our entertainment here. As many as are in favor of the motion will say "aye." There is no use in calling for the contrary minded, for the vote is unanimous.

SECRETARY JACKSON: I move you, Mr. President, that the society now take a recess until 1.15 for lunch.

Motion seconded and passed, and convention declared adjourned until 1.15.

AFTERNOON SESSION.

Convention called to order at 1.45 P. M., President Charles F. Chase in the chair.

THE PRESIDENT: Gentlemen, if you will come to order, we will continue the reading of papers and our discussions. The first paper is "The New Connecticut River Bridge of the N. Y., N. H. & H. R. R. Co. at Lyme, Conn.," by Mr. J. H. Soehrens.

Mr. Soehren's paper is printed on page 87.

Discussion will be found on page 149.

THE PRESIDENT: We passed over this morning a paper on "Some Engineering Features of the Norwich Hospital for the Insane." We

received a telegram from Mr. Chandler saying that he could not be present, and referring to Mr. Palmer, who will take his place.

Mr. Chandler's paper is printed on page 10.

Discussion will be found on page 151.

Mr. Palmer then read Mr. Chandler's paper.

THE PRESIDENT: Mr. Chandler's paper is before you for discussion.

THE PRESIDENT: The next paper on the program is "Laying of Submerged Pipes," by Frederick S. Wardwell.

THE PRESIDENT: His paper is open for discussion.

Mr. Wardwell's paper is printed on page 79.

Discussion will be found on page 152.

MR. BUSH: I would like to move that the Society elect Mr. Lewis M. Haupt, of Philadelphia, an honorary member of this society. We all appreciate his efforts in our behalf, and it is at considerable trouble that he has come up from Philadelphia for our benefit. I think it would be eminently fitting that we elect him an honorary member.

Motion seconded and unanimously carried by a standing vote.

THE PRESIDENT: Mr. Haupt is unanimously elected an honorary member of this society.

Any other motions or resolutions? Mr. Nichols spoke of something this morning that he wished to bring up.

MR. NICHOLS: The reason I spoke was that I thought perhaps it would be better to postpone that until after the papers were read; however, just a few words about it. On February 7th the *Engineering News* published a very interesting article. I won't undertake to read it all. It is an extract from the address of the President before the fifth annual convention of the Pacific Northwest Society of Engineers. I would like to see this matter brought before the society. I think it is of vital interest, and I think the best way to get at it would be to take the sense of the meeting by making a motion that the Chair appoint a committee of five or seven, as he sees fit, of engineers, to report at some future time, and submit a report for discussion, comprising a schedule of prices of minimum fixed charges which they may see fit to suggest.

THE PRESIDENT: Is the motion seconded? Did you make that as a motion?

MR. NICHOLS: I will, yes.

THE PRESIDENT: You have heard Mr. Nichols' motion, that a committee of five or seven be appointed. As it is an important matter, perhaps seven had better be appointed to consider the matter of fixing a minimum rate of charges for engineering services. Any discussion on this question?

MR. TURNER: I would like to inquire if there is any way, in the mind of Mr. Nichols, how such a regulation could be enforced, if made?

THE PRESIDENT: Of course, that is one thing that would have to be considered in connection with the whole matter. It might be very easy to fix a minimum charge, and entirely another thing to enforce it. The only way to enforce it would be for the engineers to see that it was

enforced. This is a matter that could hardly be settled at one meeting, but if the committee is appointed they can take it into consideration and report at some future meeting, and perhaps then have an extended discussion on the subject.

MR. CORSON: I should think that committee could report first as to the advisability of establishing any such scale of prices, or fixed charges, and if they advise in the affirmative and approve of any such thing, they might then follow with a certain scale of prices which they would recommend for certain work; but if such a committee is appointed now, if this motion goes through, I should think it would be well to authorize them to consider the whole question of the advisability, rather than to submit any prices.

THE PRESIDENT: Do you accept that?

MR. NICHOLS: I intended it that way.

THE PRESIDENT: To take the whole matter into consideration?

MR. NICHOLS: Yes.

THE PRESIDENT: As many as are in favor of Mr. Nichols' motion please manifest it by saying "aye." Contrary minded, "no." It is a vote.

As it is left to me to appoint the committee, I would rather take a little time to do it. Any other business?

SECRETARY JACKSON: It occurs to me in this matter of discussion of papers, etc., that very often a member might think of something after the time for discussion of a certain paper is closed that would be of considerable benefit to the society, and would be desirable to print in the proceedings, and I would suggest that if any member should think of anything they wish to submit, that the proceedings are open a month or more after this meeting, so that they can discuss by letter any point or any paper, and we could embody it in the report in that way. In fact, a great many men could sit down and write up a discussion better than they could stand up and talk it, and as we do not get our bulletins out much more than two or three days before the meeting, it is very probable that some member might wish to do that way. If so we would be glad to receive it, and I think it would be a very good thing.

THE PRESIDENT: The thing Mr. Jackson suggests is a very good one. As he said, the copy does not go to the printer for a few weeks, and if anyone has anything to say, we can easily forward your comments to Mr. Jackson, who will see that they are taken care of.

MR. CRAWFORD: I desire to give an expression of obligation to Mr. H. G. Clark for the care and patience which he gave to the work covered by his paper this morning. It took a great deal of time, and I think the result has been good. That curve is a job that I do not think anybody would long to take. I do not think there are any kinks in the work at the present time.

THE PRESIDENT: Any further questions or discussions? If not, we will take up the next paper, which is on "Telephone Subway Construction," by Mr. Edward H. Everitt.

THE PRESIDENT: Mr. Everit's paper is open for discussion. I am sure that there are some points in this that can well be discussed. Glad to hear from anyone.

Mr. Everit's paper is printed on page 96.

Discussion will be found on page 152.

SECRETARY JACKSON: I move that the thanks of the society be extended to those members who have come here to-day and given us these papers. They have been very much enjoyed by all the members present and will prove a very valuable addition to the archives of the society.

Motion seconded and unanimously passed.

MR. CORSON: Will you appoint that committee on establishing rates before this meeting adjourns?

THE PRESIDENT: I think I would rather wait until I can talk it over. It seems to be an important committee, and I would not want to appoint it now. They will be notified immediately, and the other names of the committee given.

MR. CORSON: I didn't know but they would like to know before the next meeting.

Committee of seven appointed by the President as follows:

MR. NICHOLS, New Haven,	MR. BURT, Hartford,
MR. CORSON, Hartford,	MR. BUCK, Hartford,
MR. HILL, New Haven,	MR. FORD, Bridgeport,
MR. MINER, Greenwich.	

On motion duly made, seconded and passed, the convention was declared adjourned.

Mr. Corson declining to serve, Mr. Palmer was appointed.—*Secretary*.

SUMMER MEETING.

UP THE CONNECTICUT RIVER FROM LYME BRIDGE TO
HARTFORD.

TUESDAY AUG. 14, 1906.

At 11 A. M. the steamer *Madeleine* left the Lyme steamboat dock, on the east bank of the Connecticut River, near the Lyme station of the Shore Line Division, N. Y., N. H. & H. R. R. This dock is near the Saybrook and Lyme ferry, also the site of the bridge which the railroad company is now building over the Connecticut River.

This bridge consists of ten spans, all double-track, nine of them being fixed and one movable.

Spans One to Five, inclusive, and Nine and Ten are pin-connected through (sub-panel parallel chord) truss spans each 182' 0" c. to c. of end pins; depth c. to c. of chords 35' 0"; width c. to c. of trusses 30' 8". Number of sub-panels, 14; masonry to base of rails 10' 4" at expansion end and 9' 3" at fixed end.

Span Eight is made up of two single-track deck plate girder spans each 67' 6" out to out; depth back to back of angles 7' 6¼"; width c. to c. of girders 6' 6"; masonry to base of rail 9' 3".

Span Six is a single-leaf through truss Scherzer Rolling Lift Bridge; span 158' 3" c. to c. of bearings, affording a clear channel of 152' 6" between faces of the piers under coping, measured at right angles to the channel; width of trusses c. to c. 30' 4"; masonry from top of floor 7' 3" at end and 9' 3" at center pier.

Span Seven is a track girder span 38' 0" c. to c. of bearings.

Opportunity was given to inspect the bridge work before the steamer left. The masonry work had been completed and about three spans of the heavy superstructure were erected at the time of our visit.

The steamer arrived at the famous old Portland quarries about 3 P. M., where the members enjoyed the hospitality of General Manager DePeyster, a member of the Connecticut Society of Civil Engineers. These quarries have been worked continuously since before the year 1665. They cover very many acres and the excavations extend to a depth of over 200 feet. Modern methods and machinery are to be seen here, including the handling of heavy blocks of stone by locomotive cranes, travelers, etc.

The boat arrived at Hartford at 6:30 P. M. Landing was made at the new stone bridge, which was at an interesting stage of construction. Four arches were completed and the centers removed. The main group of five arches were still on the false work and about half turned.

The scenery along the Connecticut River, between Saybrook and Hartford, in the beauty of its verdant slopes and wooded hills, rivalled that of the famous upper Hudson Valley. Each of the many bends of the

river disclosed a charming vista. The river trip was a most enjoyable feature and the descriptions of Messrs. Bishop, Wilcox and DePeyster were much enjoyed.

The luncheon served aboard the boat was appreciated and the orchestra listened to with pleasure.

The following were admitted to membership: Charles W. Bennett, Hartford, Conn.; Edwin P. Dawley, New Haven, Conn.; George R. Johnson, West Haven, Conn.; Robert L. Pearson, Saugatuck, Conn.; Albert H. Schilling, New Britain, Conn.; Philip K. Williams, Glastonbury, Conn.; Guilford D. Young, West Haven, Conn.

Those present were: Chas. F. Chase, New Britain; E. M. Stone, Hartford; F. S. Luther, Hartford; Wm. R. C. Corson, Hartford; D. S. Banta, Hartford; C. J. Bennett, Hartford; R. A. Clark, Hartford; A. B. Alderson, West Hartford; F. M. Smith, Danbury; C. R. Darrow, Waterford; G. E. Verrill, New Haven; R. F. Stoddard, Milford; W. H. Moore, New Haven; C. E. Smith, Scranton; E. C. Webster, New Haven; O. H. Marchant, New Haven; Edward E. Minor, New Haven.; Albert M. Turner, Canaan; Vincent B. Clarke, Milford; Stanley N. Clarke, Milford; Herbert B. Wightman, Norwich; E. A. Keeney, Lyme, Conn.; Robt. S. Brown, New Britain; H. W. Storrs, Meriden; James A. Toner, Newark; J. T. McKnight, Ellington; E. P. Augur, Middletown; A. H. Greenwood, Hartford; A. H. Schilling, New Britain; C. N. Merrels, New Haven; Chas. A. Ferry, New Haven; Judson M. Minor, New Haven; H. H. Gladding, New Haven; Raymond V. Root, Cromwell; Leon F. Peck, Greenwich; S. C. Pierson, Meriden; C. L. Slocum, New Haven; Geo. K. Crandall, New London; W. B. Palmer, Bridgeport; A. J. Christie, Ambridge; H. A. Weaver, Clinton; J. S. Ruff, New Haven; Edgar Tweedy Belden, New Haven; T. J. Bateman, Hoboken; Frederick DePeyster, Portland; Geo. Bishop, Middletown; Ralph Wilcox, Middletown.

CONSTITUTION.

ARTICLE I.

NAME AND OBJECT.

SECTION 1.—The name of this Society shall be the CONNECTICUT SOCIETY OF CIVIL ENGINEERS.

OBJECT.

SEC. 2.—The object of this Society shall be the professional improvement of its members; the encouragement of social intercourse among men of practical science, and the advancement of engineering in its several branches, to wit: Civil, hydraulic, naval, sanitary, mechanical, electrical, architectural, mining, geological, metallurgical, and chemical; the reading and discussion of papers, or to hear lectures on any of the above topics relating to engineering science, and the transaction of all business properly belonging to said Society.

ARTICLE II.

MEMBERSHIP.

SECTION 1.—The membership of this Society shall consist of Members, Honorary Members and Associate Members.

MEMBERS.

SEC. 2.—Members must be at least twenty-one years of age and have two years' actual experience in some branch of engineering or surveying, or shall have been graduated from an engineering course in a college or university, or recognized training, and they only shall be eligible to the office of Secretary for the Society.

HONORARY MEMBERS.

SEC. 3.—Honorary Members may be as many as the Society shall elect. They shall have no vote, but shall be eligible to hold office. They shall have the right to attend all regular meetings and to enjoy such other privileges as the Society may see fit to grant, excepting, however, such honorary Members shall be denied from *senior membership*, when the Society shall elect a person to hold office.

ASSOCIATE MEMBERS.

SEC. 4.—Persons desiring to become associated with this Society, may submit a petition for membership, may make application, and if approved by the Board of Directors, may report from the Board of Directors to the Society at the next regular meeting. The petition of the student or non-resident member at the time cast be shall be voted on by the Society. Associate Members shall be eligible to hold office, but shall not be eligible for any office.

ARTICLE III.

OFFICERS AND THEIR DUTIES.

OFFICERS.

SECTION 1.—The officers of this Society shall be, a President, two Vice Presidents, a Secretary and Treasurer, an Assistant Secretary, and four Directors.

ELECTION OF OFFICERS.

SEC. 2.—The officers, excepting the Assistant Secretary, shall be elected at the annual meeting, and shall hold their respective offices until the final adjournment of the meeting in which others are elected and qualified in their places.

PRESIDENT.

SEC. 3.—The President shall preside at all meetings when present. He shall be chairman of the Board of Direction, and of all standing committees, and shall appoint all special committees, unless otherwise ordered by a vote of the Society.

VICE PRESIDENTS.

SEC. 4.—In the absence or inability of the President to act, the Senior Vice President present shall perform his duties.

SECRETARY.

SEC. 5.—The Secretary shall attend all meetings of the Society, and the Board of Direction, and shall keep the minutes thereof. He shall conduct the general correspondence of the Society, receive communications addressed thereto, and present the same to the proper committees, officers, or meetings. He shall issue notices of all meetings, inform committees of their appointment, and officers and new members of their election. He shall notify all committees of coming meetings and prepare the matters for presentation. He shall keep a complete list of all members, with their addresses and dates of election. He shall publish the annual report. He shall perform such other duties pertaining to his office as may be imposed upon him by the Society or by the Board of Direction, and shall receive a salary to be fixed by the Society.

TREASURER.

SEC. 6.—The Treasurer shall keep the accounts, collect all the funds of the Society and shall deposit the same to the credit of the Society in such depository as may be designated by the Board of Direction. He shall pay all bills, when approved by the President or a majority of the Board of Direction. He shall keep book accounts of his receipts and expenditures, which shall at all times be open to the inspection of the Board. He shall make a duly audited itemized report to the annual meeting. He shall give bonds for the faithful performance of his

duties, in such amounts and with such sureties as the Board of Direction may require, and he shall receive such remuneration as the Society may vote to him from time to time. The Board of Direction shall audit the Treasurer's accounts and books annually.

ASSISTANT SECRETARY.

SEC. 7.—The Assistant Secretary shall be appointed annually by the President, and his duties shall be such as would pertain to the office of executive secretary.

BOARD OF DIRECTION.

SEC. 8.—This Board shall consist of the President, the two Vice Presidents, and the four Directors. It shall have supervision and care of all the affairs and property of the Society, and shall conduct the same in accordance with the Constitution and By-Laws. The President or one of the Vice Presidents shall preside at all meetings of the Board, in the order of seniority. In the absence of all these officers, a chairman *ad hoc* may be appointed for the meeting. The first year after this section is adopted, four members shall be chosen at the annual meeting, two shall be chosen for a term of one year and two to serve two years. At all subsequent annual meetings two members shall be chosen to serve two years. Four members shall constitute a quorum to transact business.

ARTICLE IV.

ELECTIONS.

OFFICERS—BY ELECTION.

SECTION 1.—At the annual meeting the Society shall elect by ballot a President, two Vice Presidents, one Secretary and Treasurer, to serve one year, and four Directors to serve two years.

SECRETARY'S DUTIES.

SECTION 2.—The Secretary shall keep on hand a list of officers to be voted for at the annual meeting. Section 3.—Each member, at least sixty days before the annual meeting, shall submit a nomination. The nominations for President, Vice President, Secretary and Treasurer, in an envelope endorsed with the name of the nominator, shall be received at least ten days from the date of the annual meeting by the Directors, and shall be delivered to the President, who shall read the nominations at a meeting to be held at least ten days before the annual meeting.

SECTION 4.—If a member nominates more than one, or other members nominate the same member, the member so nominated shall be considered as having been nominated by the majority of the nominating ballots. If the member so nominated is not nominated by any of the nominating ballots for an office, or if he is nominated by more than one nominating ballot for an office, the Board of Direction shall determine the proper nominees for that office.

All nominees for office shall be notified at once by the Secretary of their nomination and, unless the Secretary receives a prompt declination, it shall be assumed that they have accepted such nomination.

ELECTIONS, HOW CONDUCTED.

SEC. 3.—At least twenty-one (21) days before the annual meeting the Secretary shall send each member a ballot, containing the names (arranged alphabetically) of the candidates for each office. This shall be accompanied by an envelope addressed to the Secretary, with a blank space on the back for the signature of the member voting, also a blank envelope carrying no mark for recognition.

Each member shall signify his choice of candidates on the ballot and return it to the Secretary in two sealed envelopes; the inner one to be left entirely blank, and the outer one endorsed with signature of sender.

Ballots may be sent by mail to the Secretary or handed to him directly. The Secretary shall deliver the ballots, unopened, to the tellers appointed by the presiding officer.

The polls will close at eleven o'clock in the morning of the day of the regular annual business meeting of the Society.

MEMBERS IN ARREARS CANNOT VOTE.

SEC. 4.—It shall be the duty of the Treasurer to furnish the tellers with an alphabetical list of members in arrears for dues for two years or more, and no vote from a member so in arrears shall be counted. Ballots received from such members shall be returned to them unopened with a statement of the reason for such action.

PLURALITY ELECTS.

SEC. 5.—The candidate for each office receiving a plurality of the votes shall be declared elected. In case of a tie vote, the meeting shall proceed to vote by ballot for the candidates who are tied.

NOTIFICATION.

SEC. 6.—The Secretary shall officially notify in writing each officer of his election.

Officers so elected shall qualify and assume their duties immediately after the adjournment of the meeting at which they are elected, and shall hold office until their successors are duly elected and qualified.

VACANCIES.

SEC. 7.—Vacancies occurring for any cause in the list of officers shall be filled by the Board of Direction.

ELECTION OF MEMBERS.

SEC. 8.—Each application shall be announced on the notices for the next meeting after it is received, shall then be considered by the Board of Direction, and, if approved, shall be presented to the Society for

ballot at a regular meeting. If a candidate receives a majority of the ballots, he shall be declared elected. In case of rejection, no minute shall be published, but the Secretary shall notify the applicant by letter.

APPLICATION FOR MEMBERSHIP.

Sec. 9.—All applications for membership or for transfer from one grade of membership to another, shall be made on a regular form, to be secured from the Secretary, and to be endorsed by three Members. This form shall contain, immediately over the signature of the applicant, a clause in which the applicant shall agree that if elected he will be governed in all Society matters by the Constitution and By-Laws, and will forward the interest of the Society at all times.

ARTICLE V.

MEETINGS.

ANNUAL MEETING.

Section 1.—There shall be a regular annual meeting held on the second Tuesday of February each year, at such place as may be selected by the Board of Directors, of which due notice shall be given by the Secretary.

MEETINGS HOW CALLED.

Sec. 2.—Special meetings may be called by the President and, when called, the order of the meeting specifying the business thereof shall be published by the Secretary, and notice of the address of each member at which the meeting shall be held. Special meetings shall be called on the application of any ten (10) members.

QUORUM.

Sec. 3.—A majority of the membership shall constitute a quorum for the transaction of business, except for the election of officers, and for the amendment of the Constitution or By-Laws.

ARTICLE VI.

FINES.

Section 1.—The dues of Members and Associate Members shall be paid in advance, and shall be collected in advance at the annual meeting.

Section 2.—Members who do not pay full dues for that

Section 3.—The dues shall be paid in advance.

Section 4.—The Board of Directors shall have power to remit dues when the interest of the Society requires it.

ARTICLE VII.

DEPRIVATION OF MEMBERSHIP.

SECTION 1.—Any member whose dues shall remain unpaid for two (2) years shall be notified by the Treasurer, by sending by registered mail a bill for dues in arrears, on the face of which bill shall be printed the sections of the Constitution covering such cases. If the dues are not paid within thirty (30) days after such notification, the matter shall be presented to the Board of Direction, who shall have power to drop such member from the roll.

RESIGNATIONS.

SEC. 2.—Resignations must be submitted in writing to the Secretary, and may be accepted by the Board of Direction when all indebtedness to the Society has been discharged.

SEC. 3.—All charges against any member shall be investigated by the Board of Direction before being submitted to the Society.

Any member may be expelled for conduct which may be deemed prejudicial to the Society, by a two-thirds vote of the Members present at a business meeting; provided, that not less than fifteen (15) vote for expulsion, and that such member shall have had one month's notice of the charges preferred against him and of the time appointed for their consideration. All charges must fully set forth the offense or offenses alleged, and must be signed by the members preferring them. An attested copy must be furnished the accused, who shall be entitled to be present and to be heard in defense, in person or by attorney, at all meetings at which the charges are investigated, except during the time when a final vote is being taken.

ARTICLE VIII.

AMENDMENTS TO THE CONSTITUTION.

SECTION 1.—Proposed amendments to this Constitution must be presented in writing at a regular business meeting of the Society, and signed by at least three Members.

Amendments so presented shall be read at the meeting and a copy filed with the Secretary at the same time. At the meeting when presented the proposed amendments may be discussed and amended, but cannot be adopted.

SEC. 2.—At any regular business meeting the amendments previously proposed, according to Section 1, may be voted upon by letter ballot. These ballots shall be sent out with the call for the meeting and shall have the proposed amendment, together with the section of the present Constitution covering the point in question, printed upon the ballot. With the ballot shall also be sent an envelope directed to the Secretary and marked "Ballot on Amendment." The Secretary shall keep these letters unopened and present to the presiding officer all replies received

up to the hour of closing the polls. Tellers shall be appointed by the presiding officer, who shall open and count all ballots. The result shall be announced at the meeting by the presiding officer. Two-thirds of the ballots cast will be necessary for the adoption of an amendment.

Sec. 3.—The Board of Direction is authorized to number the Articles and Sections of the Constitution and By-Laws to correspond with any changes that may be made.

BY-LAWS.

MEETINGS.

1. In addition to the regular annual meeting, as provided by the Constitution, the Society shall hold at least one other general meeting, and may hold such other meetings to listen to lectures or addresses, or to visit engineering works of interest, or of a purely social nature, as the Board of Direction may decide to call.

GENERAL ORDER OF BUSINESS AT ANNUAL MEETING.

2. The following general order of business shall be observed at annual meetings:

1. Presentation of, and action upon, minutes of last meeting.
2. Report of Board of Direction.
3. Report of Secretary.
4. Report of Treasurer.
5. Report of any Special Committees.
6. Election of new members.
7. Election of officers.
8. Address of President.
9. Miscellaneous business.
10. Papers, lectures, or addresses.
11. Adjournment.

BUSINESS MEETINGS—ORDER.

3. The following general order shall be observed at Business Meetings:

1. Presentation of, and action upon, minutes of last meeting.
2. Miscellaneous announcements.
3. Stated business.
4. Adjournment.

4. Contributing Members under the old Constitution shall become Associate Members upon the adoption of the Revised Constitution.

5. Actual personal transportation expenses incurred by the Secretary in attending meetings shall be paid from the Society treasury, upon approval of the President or two members of the Board of Direction.

6. In the election of Honorary Members, a unanimous vote is necessary to elect.

7. The Society may at any time, duly named for the purpose, enact By-Laws for the future guidance, consonant with the Constitution. These By-Laws may be amended or repealed at any meeting, in the call for which meeting a copy of the proposed amendment or addition shall have been printed and sent to each member with the said notice.

PARLIAMENTARY RULES.

8. In all questions arising at any meeting, involving parliamentary rules, not provided for in these By-Laws, Roberts' Rules of Order shall be the governing authority.

VISITORS.

9. Visitors may be admitted to meetings under such rules as the meeting may prescribe.

10. All forms, such as blanks for application for membership, ballots for officers, ballots on amendments to Constitution or By-Laws, and other necessary blanks for the conduct of the business of the Society, shall be prepared by the Secretary and approved by the Board of Direction.

List of Members.

With Addresses and Dates of Election.

Members are particularly requested to inform the Secretary at once of any change in address.

HONORARY MEMBERS.

CHITTENDEN, PROF. RUSSELL H.	April 20, 1901
Dean of Sheffield Scientific School of Yale University, New Haven, Conn.	
CLARK, EDGAR	June, 1887
Putnam, Conn.	
CLARK, JOHN E.	April, 1884
Prof. Mathematics, Emeritus, at Sheffield Scientific School, Yale University, South Terrace, Longmeadow, Mass.	
FITZGERALD, DESMOND	Jan. 8, 1901
Consulting Engineer, Brookline, Mass.	
FROST, GEORGE H.	April, 1884
President Engineering News Publishing Co., New York.	
HADLEY, DR. ARTHUR T.	April 20, 1901
President Yale University, New Haven, Conn.	
HAUPT, LEWIS	Feb. 12, 1907
Consulting Engineer, Philadelphia, Pa.	
HAYNES, EDWARD C.	Jan. 14, 1890
Ware, Mass.	
PETTEE, WILLIAM E.	Jan. 10, 1899
Civil Engineer, Salisbury, Conn.	
SEYMOUR, WILLIAM O.	Feb. 9, 1904
Railroad Commissioner, Ridgefield, Conn.	
SKINNER, FRANK W.	Jan. 9, 1900
Editorial Staff of the Engineering Record, New York.	
SCOFIELD, HORACE G.	Feb. 14, 1906
Civil Engineer, Bridgeport, Conn.	

MEMBERS.

ADAMS, JULIUS L.	July 18, 1899
Civil Engineer Hartford, Manchester and Rockville Tramway Co., South Manchester, Conn.	
ALDERSON, ALGERNON B.	Jan. 10, 1899
Town Engineer, West Hartford, Conn.	
AMRHYN, GUSTAVE X.	Feb. 9, 1904
Associate Member, Department of Parks, New Haven, Conn.	
AUGUR, EDWIN P.	April, 1884
Civil Engineer and Surveyor, and City Surveyor, Middletown, Conn.	

LIST OF MEMBERS.

213

AYRES, HENRY W.	Jan. 13, 1885
Hydraulic Engineer, Hartford, Conn.	
AZHDERIAN, REUBEN B.	Feb. 12, 1907
Engineering Department, N. Y., N. H. & H. R. R., Waterbury, Conn.	
BACON, ARTHUR W.	Feb. 9, 1904
Civil Engineer, New Britain, Conn.	
BANTA, D. SCHUYLER	Aug. 23, 1905
Civil Engineer, Hartford, Conn.	
BARKER, WILLIAM H.	Aug. 10, 1904
Jenkins & Barker, Hartford, Conn.	
BARNEY, SAMUEL E.	Jan. 9, 1900
Prof. Civil Engineering Sheffield Scientific School, Yale University, New Haven, Conn.	
BEACH, CHARLES EDWARD	Jan. 10, 1893
Civil Engineer, West Hartford, Conn.	
BELDEN, CLIFFORD H.	March 30, 1900
Civil Engineer, Hartford, Conn.	
BELDEN, EDGAR T.	Jan. 8, 1901
Warner-Miller Co., New Haven, Conn.	
BENNETT, CHAS. J.	Aug. 14, 1906
Engineering Department, N. Y., N. H. & H. R. R. Co., Hartford, Conn.	
BENNETT, RAYMOND F.	March 30, 1900
W. F. Bennett & Son, Contractors, Portland, Maine.	
BERRIAN, RICHARD M.	Jan. 9, 1900
Chief Engineer Fall River Bridge, Fall River, Mass.	
BERRY, CHARLES H.	Aug. 10, 1904
Civil Engineer, Flatbush, N. Y.	
BISHOP, GEORGE H.	Jan. 13, 1885
Hydraulic Engineer, Middletown, Conn.	
BISSELL, CLINTON T.	Aug. 10, 1904
Civil Engineer, Brooklyn, N. Y.	
BLACK, WILLIS J.	Feb. 13, 1906
Civil Engineer N. Y., N. H. & H. R. R., New Haven, Conn.	
BLAIR, CLARENCE M.	Aug. 10, 1904
Civil Engineer, New Haven, Conn.	
BLAKESLEE, CLARENCE	Jan. 9, 1900
Civil Engineer and Contractor, New Haven, Conn.	
BLATCHLEY, WILLIAM J.	Aug. 10, 1904
Civil Engineer, New Haven, Conn.	
BLEIM, DANIEL WILLIAM	Feb. 12, 1907
Manager American Bridge Co., East Berlin, Conn.	
BODFISH, HENRY L.	Feb. 13, 1906
Civil Engineer, N. Y., N. H. & H. R. R. Co., Derby, Conn.	
BRADLEY, DANIEL E.	Jan. 9, 1894
President Berlin Construction Co., Berlin, Conn.	
BRETT, THOMAS C.	Aug. 10, 1904
Secretary Yale Safe & Iron Works, New Haven, Conn.	
BREWER, WILLARD SEYMOUR	Feb. 12, 1907
City Engineer's Office, Hartford, Conn.	
BRINSMADE, DANIEL E.	April 20, 1901
Secretary and Assistant Engineer Ousatonic Water Co., Shelton, Conn.	
BRINSMADE, D. S.	April, 1884
Engineer Housatonic Water Power Co., Derby, Conn.	

BROWN, CHARLES O.	Jan. 11, 1892
City Engineer, Danbury, Conn.	
BROWN, EDMUND	Jan. 12, 1899
Superintendent and Engineer of Norfolk Water Co., Norfolk, Conn.	
BROWN, WALTER A.	Oct. 11, 1902
First Assistant City Engineer, Springfield, Mass.	
BROWN, WALTER A.	Feb. 13, 1906
Civil Engineer with J. D. Barker, Springfield, Mass.	
BROWN, WALTER R.	Feb. 13, 1906
Engineering Dep't, N. Y., N. H. & H. R. R., Waterbury, Conn.	
BUCK, HENRY R.	Jan. 10, 1899
Consulting Engineer, Hartford, Conn.	
BUDDINGTON, JOHN E.	March 30, 1903
Consulting Engineer and Contractor, New Haven, Conn.	
BUNCE, CHARLES H.	April, 1884
Civil Engineer, Hartford, Conn.	
BURGHARDT, WALLACE	Feb. 13, 1906
Town Engineer, North Canaan, Conn.	
BURT, LUTHER HAROLD	Aug. 14, 1900
Bronx Valley Sewer Commission, White Plains, N. Y.	
BURT, LUTHER W.	Jan. 13, 1885
Civil Engineer and Surveyor, Hartford, Conn.	
BUSCHOR, EMIL CHARLES	Jan. 10, 1899
Civil Engineer and Surveyor, Central Valley, New York.	
BUSH, EDWARD W.	Jan. 10, 1899
Assistant Engineer Conn. River Bridge and Highway District, Hartford, Conn.	
BUSHNELL, W. G.	Feb. 14, 1905
Associate Member, Electrical Engineer, New Haven, Conn.	
CADWELL, WILLIAM H.	May 31, 1893
Civil Engineer, New Britain, Conn.	
CAHN, ALEXANDER	Jan. 9, 1900
Civil Engineer, New Haven, Conn.	
CAIRNS, ROBERT A.	Aug. 29, 1890
Sanitary and Hydraulic Engineer and City Engineer, Waterbury, Conn.	
CARD, HUBER D.	Oct. 24, 1895
Card & Smith, Civil Engineers and Surveyors, Putnam, Conn.	
CARLISLE, HARRY E.	Jan. 9, 1900
Conduit Engineer, S. N. E. Telephone Co., New Haven, Conn.	
CARTER, RALPH B.	Jan. 14, 1890
Civil Engineer, 26 Cortlandt St., New York.	
CAUM, FRANK	Aug. 14, 1900
General Manager Scranton Railway Co., Scranton, Pa.	
CHANDLER, CHARLES E.	April, 1884
Civil Engineer, Norwich, Conn.	
CHAPMAN, FREDERICK S.	Feb. 10, 1903
Civil Engineer, Philippine Islands.	
CHASE, CHARLES F.	March 30, 1900
Engineer Berlin Construction Co., New Britain, Conn.	
CHENEY, RICHARD OTIS, JR.	Jan. 9, 1900
Civil Engineer, South Manchester, Conn.	
CLARK, HERBERT G.	July 18, 1899
Engineer of Keney Park, Hartford, Conn.	
CLARK, ROSCOE N.	July 18, 1899
Assistant City Engineer, Hartford, Conn.	

LIST OF MEMBERS.

215

CLARK, VINCENT B.	Feb. 9, 1904
Civil Engineer, Milford, Conn.	
CLARK, WILLIAM S.	July 14, 1890
Civil Engineer, Meriden, Conn.	
COE, THEODORE I.	Jan. 9, 1900
Architect, 100 William St., New York.	
COGGESHALL, R. C. P.	June, 1887
Superintendent of Water Works, New Bedford, Mass.	
COLE, CLINTON L.	Feb. 9, 1904
Civil Engineer, Conn. River Bridge & Highway District, Hartford, Conn.	
COLLINS, HARRY C.	July 18, 1899
Berlin Construction Co., Boston, Mass.	
COMSTOCK, LEWIS B.	Aug. 10, 1904
Civil Engineer, New Rochelle, N. Y.	
COOLEY, ORRIN F.	Aug. 10, 1904
Civil Engineer, Springfield, Mass.	
CORSON, WILLIAM R. C.	Feb. 10, 1903
Electrical Engineer, Hartford, Conn.	
CRANDALL, GEORGE K.	Jan. 11, 1887
City Engineer, New London, Conn.	
CRAWFORD, CHARLES M.	July 18, 1899
Chief Engineer Northern Traction Co., Hamilton, Ohio.	
CRAWFORD, NORMAN McDONALD	July 18, 1899
Consulting Engineer, Cincinnati, Ohio.	
CURTIS, FAYETTE S.	Jan. 9, 1900
Vice President N. Y., N. H. & H. R. R., Boston, Mass.	
CURTIS, THEODORE ALLEN	Aug. 14, 1900
Windsor, Conn.	
CURTISS, GREY WILLIS	Feb. 12, 1907
Civil Engineer, N. Y., N. H. & H. R. R. Co., New Haven, Conn.	
DABOLL, LOREN E.	Jan. 8, 1895
Civil Engineer, New London, Conn.	
DARROW, COURTLAND R.	Jan. 8, 1895
Civil Engineer, Waterford, Conn.	
DAVIS, ARTHUR L.	July 18, 1899
Assistant Manager Eastern District and Export, American Bridge Co., 100 Broadway, New York.	
DAVIS, F. IRWIN	Oct. 11, 1902
Architect, Hartford, Conn.	
DAWLEY, EDWIN P.	Aug. 14, 1906
Engineer of Construction N. Y., N. H. & H. R. R., New Haven, Conn.	
DEPEYSTER, FREDERICK	Sept. 3, 1891
General Manager Brainard, Schaler & Hall Quarry, Portland, Conn.	
DEYO, SOLOMON LEF.	Jan. 9, 1900
Chief Engineer New York Rapid Transit Subway Construction Co., New York City, N. Y.	
DuBOIS, AUGUSTUS J.	Jan. 9, 1900
Prof. Civil Engineering Sheffield Scientific School, Yale University, New Haven, Conn.	
DUNCAN, EDGAR T.	Feb. 14, 1905
Civil Engineer, Hartford, Conn.	
DUNHAM, WILLIAM ROBERT, JR.	Feb. 12, 1907
Civil Engineer Consolidated Railway Co., New Haven, Conn.	

EASTERBROOK, FREDERICK J.	March 30, 1900
Assistant Engineer, N. Y., N. H. & H. R. R. Co., New Haven, Conn.	
EDDY, CHARLES W.	Jan. 9, 1900
Civil Engineer, Waterbury, Conn.	
ELLSWORTH, FREDERICK H.	March 30, 1900
Division Engineer, N. Y., N. H. & H. R. R. Co., New Haven, Conn.	
EVERIT, EDW. H.	Oct. 11, 1902
Engineer S. N. E. Telephone Co., New Haven, Conn.	
FARNHAM, CHARLES S.	Feb. 9, 1904
Instructor Civil Engineering Sheffield Scientific School, Yale University, New Haven, Conn.	
FERRY, CHARLES A.	Jan. 9, 1900
Civil Engineer and Surveyor, New Haven, Conn.	
FORBES, HENRY DEB.	April 20, 1901
Civil Engineer, College Hill, Ky.	
FORD, FREDERICK L.	Jan. 12, 1897
City Engineer, Hartford, Conn.	
FORD, THEODORE B.	April 20, 1901
Civil Engineer, Bridgeport, Conn.	
FULTON, WILL H.	Jan. 8, 1901
City Engineer's Office, New Haven, Conn.	
GAGEL, EDWARD	Jan. 9, 1900
Chief Engineer N. Y., N. H. & H. R. R. Co., New Haven, Conn.	
GILLETTE, GEORGE W. F.	Jan. 9, 1900
G. M. Grant Co., New Haven, Conn.	
GLADDING, HENRY H.	Jan. 9, 1900
Assistant City Engineer, New Haven, Conn.	
GOSS, EDWARD O.	Nov. 29, 1890
Assistant Treasurer Scovil Mfg. Co., Waterbury, Conn.	
GRAVES, EDWIN D.	Oct. 25, 1895
Chief Engineer Conn. River Bridge and Highway District, Hartford, Conn.	
GREENWOOD, ALBERT H.	Feb. 9, 1904
With Berlin Construction Co., Berlin, Conn.	
GREGORY, J. LOUIS	Aug. 10, 1904
Civil Engineer, Larchmont, N. Y.	
HALE, PERRY T. W.	Feb. 10, 1903
Superintendent Middletown Water Works, Middletown, Conn.	
HALL, A. CLARK	Jan. 8, 1901
Hartford Water Department, West Hartford, Conn.	
HALL, CHARLES ERNEST	Feb. 12, 1907
Civil Engineer, Consolidated Railway Co., New Haven, Conn.	
HALL, WILLIAM HENRY	Feb. 12, 1907
Engineering Department, N. Y., N. H. & H. R. R., New Haven, Conn.	
HAND, GEORGE F.	Feb. 13, 1906
Civil Engineer, West Haven, Conn.	
HANS, ALEXANDER JOSEPH	Feb. 12, 1907
Civil Engineer, Stamford, Conn.	
HARRISON, IRVING WARREN	Feb. 12, 1907
City Engineer's Office, Waterbury, Conn.	
HARTE, CHARLES R.	Aug. 10, 1904
Civil Engineer, N. Y., N. H. & H. R. R., New Haven, Conn.	
HASTINGS, F. B., Associate Member	Feb. 10, 1903
B. D. Pierce Co., Bridgeport, Conn.	

LIST OF MEMBERS.

217

HATCH, CHARLES	Feb. 13, 1906
Civil Engineer, N. Y., N. H. & H. R. R. Co., New Haven, Conn.	
HAWLEY, ARTHUR S.	Feb. 11, 1902
C. W. Blakeslee & Co., New Haven, Conn.	
HAZELTINE, LOUIS R.	Feb. 11, 1902
Architect, 94 State St., New London, Conn.	
HEITMAN, ADRIAN C., JR.	Feb. 10, 1903
Civil Engineer, West Haven, Conn.	
HENDERSON, JOHN T.	July 18, 1899
Assistant Engineer Conn. River Bridge and Highway District, Hartford, Conn.	
HILL, ALBERT B.	Jan. 9, 1900
Civil and Consulting Engineer, New Haven, Conn.	
HINE, FRANK E.	April 20, 1901
Civil Engineer, Fisher's Island, N. Y.	
HOSLEY, ROBERT M.	Aug. 23, 1905
Civil Engineer N. Y., N. H. & H. R. R. Co., New Haven, Conn.	
HOYT, FRANK N.	July 18, 1899
Civil Engineer State Highway Commissioner's Office, Hartford, Conn.	
HOYT, SAMUEL N., JR.	Feb. 9, 1904
Civil Engineer, South Norwalk, Conn.	
HULBERT, ROBERT S.	April, 1884
Civil Engineer, Winsted, Conn.	
HULBERT, TIMOTHY ANDREW	Feb. 12, 1907
Engineering Department, American Brass Co., Waterbury, Conn.	
INGERSOLL, C. M., JR.	Jan. 8, 1901
Chief Engineer, Department of Bridges, New York, N. Y.	
JACKSON, J. FREDERICK	Jan. 9, 1900
Civil Engineer, New Haven, Conn.	
JAMESON, MINOR S.	Feb. 9, 1904
Assistant Engineer, N. Y., N. H. & H. R. R. Co., New Rochelle, N. Y.	
JARVIS, CHARLES M.	April, 1884
Vice President P. & F. Corbin Co., New Britain, Conn.	
JAYNES, FRANK B.	Feb. 10, 1903
Civil Engineer, Bridgeport, Conn.	
JOHNSON, GEORGE R.	Aug. 14, 1906
Civil Engineer, West Haven, Conn.	
JOHNSON, WILLIAM D.	Aug. 14, 1900
Architect, Hartford, Conn.	
JOHNSON, WILLIAM E.	Nov. 29, 1890
Engineer of Hartford Water Works, West Hartford, Conn.	
JONES, EDWIN J.	Feb. 9, 1904
Civil Engineer, Springfield, Mass.	
JONES, WALTER A.	Feb. 10, 1903
Civil Engineer, New Haven, Conn.	
KEENEY, ERNEST A.	Feb. 14, 1905
Civil Engineer, N. Y., N. H. & H. R. R. Co., Lyme, Conn.	
KEHR, HARRY T.	Aug. 10, 1904
Civil Engineer, 330 W. 4th St., New York, N. Y.	
KEITH, HERBERT C.	Jan. 9, 1900
Consulting Engineer, 1213 Morton Bldg., 116 Nassau St., New York City.	
KELLOGG, HENRY J.	April, 1884
First Assistant City Engineer, New Haven, Conn.	

KELLY, CASSIUS W.	Jan. 9, 1900
City Engineer, New Haven, Conn.	
KIRBY, RICHARD S.	March 30, 1900
Instructor in Civil Engineering, Sheffield Scientific School, Yale University.	
New Haven, Conn.	
KITCHEN, FRANK H.	Jan. 8, 1901
Civil Engineer, Buffalo, N. Y.	
KOPCZYNSKI, LEON	Feb. 12, 1907
Civil Engineer, New Haven, Conn.	
LAFORGE, FREDERICK W.	Jan. 13, 1885
U. S. Engineer, Fort Terry, Plum Island, N. Y.	
LANE, JOHN S.	Jan. 9, 1901
John S. Lane & Sons, Meriden, Conn.	
LANE, E. LEROY	Jan. 8, 1901
Contractor, Hingham, Mass.	
LAW, WALTER H.	Aug. 10, 1904
Civil Engineer, Fall River, Mass.	
LAWTON, EDWIN F.	March 30, 1900
Superintendent Hartford Electric Light Co., Hartford, Conn.	
LEACH, SMITH S.	Jan. 8, 1901
Major Engineers, U. S. Government, Washington, D. C.	
LEE, EDWIN M.	Feb. 10, 1903
Civil Engineer, Gardner, Mass.	
LEWIS, ROBERT P.	Oct. 24, 1895
Secretary Blake & Johnson, Waterbury, Conn.	
LIBBEY, JOSEPH H.	Feb. 13, 1906
Assistant Electrical Engineer, N. Y., N. H. & H. R. R.,	
New Haven, Conn.	
LOCHRIDGE, ELBERT E.	Aug. 23, 1905
Civil Engineer, Springfield, Mass.	
LOOMIS, FRANK W.	July 18, 1899
Civil Engineer and Surveyor, Hartford, Conn.	
LUTHER, FLAVEL S., JR.	Feb. 9, 1904
President Trinity College, Hartford, Conn.	
LYON, C. T.	Feb. 12, 1907
Engineering Department, N. Y., N. H. & H. R. R., New Haven, Conn.	
MALONEY, DENNIS J.	April 20, 1901
Superintendent of Buildings, Board of Education, New Haven, Conn.	
MALONEY, FRANK A.	Jan. 9, 1900
Assistant City Engineer, New Haven, Conn.	
MANNING, GEORGE E.	Jan. 11, 1898
Civil Engineer, Yantic, Conn.	
MARCHANT, ORSON H.	Feb. 14, 1905
Civil Engineer, New Haven, Conn.	
McKENZIE, J. M.	April, 1884
Civil Engineer and Surveyor, Yalesville, Conn.	
McKENZIE, THEODORE H.	April, 1888
Sanitary and Hydraulic Engineer, Southington, Conn.	
McKENZIE, THOMAS	Feb. 12, 1907
Superintendent of Water Works and Town Engineer, Westerly, R. I.	
McKNIGHT, JOHN T.	May 31, 1893
City Engineer, Rockville. Residence, Ellington, Conn.	
McLEAN, GEORGE H.	Feb. 9, 1904
Civil Engineer, New Haven, Conn.	

LIST OF MEMBERS.

219

MERRELS, CHARLES W.	Jan. 9, 1900
City Engineer's Office, New Haven, Conn.	
MILLER, GEORGE S.	Aug. 22, 1901
Civil Engineer U. S. Fortification, Fisher's Island, N. Y.	
MINOR, EDWARD E.	Feb. 9, 1904
Civil Engineer, New Haven, Conn.	
MINOR, JUDSON M.	Feb. 13, 1906
City Engineer's Office, New Haven, Conn.	
MINOR, SHELDON E.	Sept. 25, 1886
Civil Engineer, Greenwich, Conn.	
MITCHELL, ROBERT E.	Jan. 9, 1900
Civil Engineer and Surveyor, Willimantic, Conn.	
MOORE, WM. HARLEY	Jan. 9, 1900
Engineer of Bridges, N. Y., N. H. & H. R. R., New Haven, Conn.	
MORTON, WALTER S.	Aug. 10, 1904
Civil Engineer, Hartford, Conn.	
MOSS, ERNEST B.	April 20, 1901
Civil Engineer, H. Wales Lines Co., Meriden, Conn.	
MURPHY, HAROLD T.	Feb. 9, 1904
Civil Engineer, Springfield, Mass.	
MURPHY, JOHN P.	July 18, 1899
City Engineer's Office, Hartford, Conn.	
NASH, PAUL	Jan. 9, 1900
City Engineer and Surveyor, Stamford, Conn.	
NICHOLS, CHARLES H.	Jan. 8, 1901
Consulting Engineer and Engineer of Shell Fish Commission, New Haven, Conn.	
NOBLE, EDWARD J.	Jan. 8, 1901
Hartford, Conn.	
NOERR, ROBERT COLLYER	Feb. 12, 1907
Civil Engineer, Berlin Construction Co., Hartford, Conn.	
O'CONNOR, DON, Associate Member	Feb. 9, 1904
D. F. Keenan, Hartford, Conn.	
OLDERSHAW, FRANCIS H.	Jan. 8, 1901
City Engineer, New Britain, Conn.	
OLMSTED, C. HENRY	July 18, 1899
Civil Engineer and Surveyor, East Hartford, Conn.	
OLSEN, JOHN	Feb. 12, 1907
Civil Engineer, Springfield, Mass.	
OSBORNE, FRED H.	Jan. 9, 1900
Civil Engineer Consolidated R. R., New Haven, Conn.	
OWEN, ELIJAH H.	March 30, 1900
Care of Vorce Engineering Co., Perry-Payne Bldg., Cleveland, Ohio.	
PALMER, GEORGE E.	March 30, 1900
Assistant Engineer N. Y., N. H. & H. R. R., West Haven, Conn.	
PALMER, SHEPARD B.	Jan. 8, 1895
Civil Engineer and Surveyor, Norwich, Conn.	
PALMER, WILLIAM B.	Jan. 13, 1885
Civil Engineer and Surveyor, Bridgeport, Conn.	
PARDEE, WILLIAM S., Associate Member	Aug. 10, 1904
Wright & Pardee, New Haven, Conn.	
PARKER, GEORGE A.	July 18, 1899
Superintendent of Keney Park, Hartford, Conn.	

LIST OF MEMBERS.

221

ROOT, CLIFFORD ANSON	Feb. 12, 1907
Civil Engineer, Hartford, Conn.	
RUFF, JOHN S.	Feb. 12, 1907
Engineering Department, N. Y., N. H. & H. R. R., New Haven, Conn.	
RYDER, ELY M. T.	Jan. 9, 1900
Construction Engineer Consolidated Railway, New Haven, Conn.	
SAGE, GEORGE H.	Jan. 8, 1895
Vice President Berlin Construction Co., Berlin, Conn.	
SCHILLING, ALBERT H.	Aug. 14, 1906
Berlin Construction Co., New Britain, Conn.	
SELLARS, PHILIP	Feb. 9, 1904
Civil Engineer, New Haven, Conn.	
SHAUGNESSY, JAMES F.	Feb. 11, 1902
Board of Water Commission, Hartford, Conn.	
SHAW, GEO. H.	Aug. 23, 1905
Assistant Engineer Board of Water Supply, 299 Broadway, N. Y.	
SHELDON, PAUL	Feb. 12, 1907
City Engineer's Office, Hartford, Conn.	
SLOCUM, CURLYS L.	Aug. 25, 1905
Assistant Engineer Bridges, N. Y., N. H. & H. R. R., New Haven, Conn.	
SMITH, FRANK M.	Aug. 23, 1905
Engineering Department, N. Y., N. H. & H. R. R. Co., Danbury, Conn.	
SMITH, GEORGE E.	Feb. 10, 1903
Assistant City Engineer, Derby, Conn.	
SMITH, WILLIAM G.	April, 1884
Civil Engineer and Surveyor, Waterbury, Conn.	
SNELL, EDWARD B.	Feb. 13, 1906
Civil Engineer, New Haven, Conn.	
SNELL, HARRY B.	Jan. 8, 1901
Civil Engineer, Brooklyn, N. Y.	
SOEHRENS, JOHN H.	Aug. 10, 1904
Civil Engineer, N. Y., N. H. & H. R. R., New London, Conn.	
SPENCER, NORMAN C.	Jan. 8, 1901
Spencer & Washburn, Civil Engineers, Hartford, Conn.	
SPENCER, WALTER T.	Jan. 9, 1900
Division Engineer, N. Y., N. H. & H. R. R., New Haven, Conn.	
SPERRY, A. WILLIAM	Jan. 9, 1900
Civil Engineer and Surveyor, New Haven, Conn.	
SPERRY, HARTLEY W.	Feb. 9, 1904
Associate Member, Short Beach, Conn.	
STEARNS, ELMER W.	Oct. 11, 1902
Civil Engineer, Berlin, Conn.	
STILES, EDGAR H.	Oct. 11, 1902
Civil Engineer, N. Y., N. H. & H. R. R., Cos Cob, N. Y.	
STERLING, PAUL	Oct. 11, 1902
N. Y., N. H. & H. R. R. Co., Bridgeport, Conn.	
STODDARD, RAYMOND FRENCH	Jan. 9, 1900
Assistant Engineer Fall River Bridge, Fall River, Mass.	
STONE, EDWARD M.	July 18, 1899
Civil Engineer and Surveyor, Hartford, Conn.	
STORY, ISAAC M.	Feb. 13, 1906
Civil Engineer, N. Y., N. H. & H. R. R., New Haven, Conn.	
STORRS, HARRY W.	Aug. 23, 1905
Civil Engineer, Meriden, Conn.	

- SULLIVAN, JOHN M. Aug. 10, 1904
Civil Engineer, N. Y., N. H. & H. R. R., New Haven, Conn.
- TAYLOR, EDWY L. Feb. 13, 1906
Instructor in Civil Engineering, Sheffield Scientific School, Yale
University, New Haven, Conn.
- TAYLOR, LUCIAN A. June, 1887
Civil Engineer and Contractor, Boston, Mass.
- TAYLOR, WILLIAM T. Feb. 9, 1904
Civil Engineer, Hartford, Conn.
- TERRY, ALFRED H. Feb. 11, 1900
Division Engineer, N. Y., N. H. & H. R. R., New Haven, Conn.
- THOMAS, JAMES B. Jan. 9, 1900
Civil Engineer and Surveyor, Hartford, Conn.
- TONER, JAMES A. Aug. 23, 1905
Sanborn Map Co., 11 Broadway, New York City.
- TRACY, JOHN C. Jan. 9, 1900
Assistant Professor of Structural Engineering, Yale University,
New Haven, Conn.
- TRUESDELL, WALTER E. June 11, 1898
Civil Engineer, 160 5th Ave., New York, N. Y.
- TRUMBULL, JOHN F. Aug. 10, 1904
Civil Engineer, N. Y., N. H. & H. R. R., New Haven, Conn.
- TURNER, ALBERT M. Aug. 10, 1905
Civil Engineer, Canaan White Lime Co., Canaan, Conn.
- UNKELBACH, MAX J. Jan. 9, 1900
Architect and Civil Engineer, New Britain, Conn.
- VERRILL, GEORGE E. Feb. 11, 1902
U. S. Assistant Engineer, New Haven, Conn.
- VORCE, CLARENCE B. Jan. 10, 1899
John F. Kelly Engineering Co., New York City.
- WADHAMS, JOSEPH P. Feb. 9, 1904
Civil Engineer, New Haven, Conn.
- WADSWORTH, A. R. Oct. 27, 1886
Civil Engineer and Surveyor, Farmington, Conn.
- WARDWELL, FREDERICK S. Feb. 9, 1904
Civil Engineer, Stamford, Conn.
- WASHBURN, ALBERT L. Jan. 10, 1899
City Engineer's Office, Hartford, Conn.
- WATSON, WILLIAM C. Feb. 13, 1906
Engineering Department, N. Y., N. H. & H. R. R., New Haven, Conn.
- WEAVER, HALSEY A. Jan. 12, 1897
Civil Engineer, N. Y., N. H. & H. R. R., New Haven, Conn.
- WELTON, NELSON J. April, 1884
Civil and Hydraulic Engineer, Waterbury, Conn.
- WILLIAMS, PHILIP K. Aug. 14, 1906
Assistant Superintendent J. B. Williams Co., Glastonbury, Conn.
- WHEELER, CHAS. A. Jan. 8, 1901
Prof. of Mathematics, Conn. Agricultural College, Storrs, Conn.
- WHITE, HOWARD E. Feb. 9, 1904
New Haven Gas Light Co., New Haven, Conn.
- WHITNEY, ELI March 30, 1900
President New Haven Water Co., New Haven, Conn.
- WHITON, FRANK W. Feb. 14, 1905
Associate Member. Architect, Hartford, Conn.

LIST OF MEMBERS.

223

WIGGIN, ERNEST W.	March 30, 1900
Engineer Bridges & Buildings, Missouri Pacific Ry., St. Louis, Mo.	
WILCOX, RALPH M.	Jan. 8, 1901
Civil Engineer, Middletown, Conn.	
WILKES, J. K.	April, 1884
City Engineer, New Rochelle, New York.	
WOLCOTT, HENRY A.	July 18, 1899
Mechanical and Civil Engineer, Hartford, Conn.	
WOOD, CHAS. N.	Aug. 14, 1900
Civil Engineer, Norwalk, Conn.	
YOUNG, GUILFORD D.	Feb. 13, 1906
Civil Engineer, West Haven, Conn.	

ALPHABETICAL LIST OF ADVERTISERS

Name	Business	Page
Alpha Portland Cement Co.	Cement	2
Alsen Portland Cement Co.	Cement	4
American Pipe Manufacturing Co., The.	Cast Iron Pipe and Contractors	3
American Sewer Pipe Co., The	Vitrified Sewer Pipe	5
Atlas Portland Cement Co.	Cement	6
Balf Co., The Edward	Teaming and Contracting	31
Berger, C. L. & Sons	Engineering Instruments	22
Berlin Construction Co., The	Steel Structures	(back cover)
Blakeslee, C. W. & Sons	Contractors	33
Brodie Co., The William H.	Steel Rolling Doors, etc.	7
Buffalo Steam Roller Co.	Road Rollers, etc.	8
Connecticut Trap Rock Quarries, The	Trap Rock	33
Consolidated Rosendale Cement Co., The	Rosendale Cement	(inside front cover)
Contractors' Supply & Equipment Co., The	Concrete Mixers	32
Detroit Graphite Manufacturing Co., The	Paint	11
Dixon Crucible Co., The Joseph	Paint	9
Eastern Expanded Metal Co., The	Expanded Metal	14
Eddy, George M. & Co.	Tapes	13
Edson Manufacturing Co., The	Pumps	12
Engineering News, The	Magazine	28
Engineering Record, The	Magazine	22
Grant, C. L.	Borings	26
Gurley, W. & L. E.	Engineering Instruments (inside back cover)	10
Harrington, Robinson & Co.	Rails	15
Hartford Paving & Construction Co., The	Pavements and Concrete	16
Hendricks Co., S. E.	Commercial Register	17
Hering, Rudolf, and Fuller, Geo. W.	Hydraulic and Sanitary Engineers	17
Higgins, Charles M. & Co.	Drawing Inks	31
Kearns, W. F. & Co.	Concrete Steel and Fireproofing	19
Keenan, D. F.	Crushed Stone	34
Keuffel & Esser Co.	Engineering Instruments, etc.	17
Kolesch & Co.	Engineering Instruments	20
Lines Co., The H. Wales	Sewer Pipe, Stone and Cement	24
Lorain Steel Co., The	Rails	23
Ludlow Valve Manufacturing Co., The	Gate Valves	17
Lufkin Rule Co., The	Tapes and Rules	25
New York Brick & Paving Co., The	Vitrified Paving Brick	37
Pacific Flush Tank Co., The	Miller Automatic Siphon	27
Rail Joint Co., The	Rail Joints	29
Scherzer Rolling Lift Bridge Co., The	Lift Bridges	26
Sessions Foundry Co., The	Sewer Castings, etc.	22
Soltmann, E. G.	Drawing Materials	38
St. Marys Sewer Pipe Co.	Vitrified Sewer Pipe	28
Stoddard-Brown Co., The	Engraving	18
United Building Material Co.	See Lesley & Trinkle	21
Tuttle, Morehouse & Taylor Co., The	Printers and Publishers	35
Warner-Miller Co., The	Cement, Blue Stone, Sewer Pipe, etc.	38
Warren Brothers Co., The	Bitulithic Pavement	13
Warren Foundry & Machine Co., The	Cast Iron Pipe	30
Whitehall Portland Cement Co., The	Cement	30

CLASSIFIED LIST OF ADVERTISERS

BLUE PRINTS.	
E. G. Soltmann	22
Keuffel & Esser Co.	34
BORINGS.	
C. L. Grant	26
BRICK.	
The New York Brick & Paving Co.	25
The Warner-Miller Co.	35
BRIDGES.	
Berlin Construction Co.	(back cover)
The Scherzer Rolling Lift Bridge Co.	29
CAST IRON PIPE.	
The American Pipe Manufacturing Co.	3
Warren Foundry & Machine Co.	13
CEMENT.	
The Atlas Portland Cement Co.	6
Alpha Portland Cement Co.	2
Alsen Portland Cement Co.	4
Consolidated Rosendale Cement Co.	(inside front cover)
The Whitehall Portland Cement Co.	30
The Warner-Miller Co.	35
The United Building Material Co.	18
The H. Wales Lines Co.	20
CONCRETE.	
The Hartford Paving & Construction Co.	15
W. F. Kearns Co.	31
CONCRETE MIXERS.	
Contractors' Supply & Equipment Co.	32
CONTRACTORS.	
The Hartford Paving & Construction Co.	15
C. W. Blakeslee & Sons.	33
The American Pipe Manufacturing Co.	3
The Edward Balf Co.	31
The H. Wales Lines Co.	20
CRUSHED STONE.	
Connecticut Trap-Rock Quarries	32
D. F. Keenan	19
DRAWING MATERIALS.	
W. & L. E. Gurley	(inside back cover)
Keuffel & Esser	34
E. G. Soltmann	22
Charles M. Higgins & Co.	17
ENGINEERS' AND SURVEYORS' INSTRUMENTS.	
C. L. Berger & Sons.	22
George M. Eddy & Co.	13
W. & L. E. Gurley	(inside back cover)
Keuffel & Esser Co.	34
Kolesch & Co.	17
The Lufkin Rule Co.	17
ENGINEERING MAGAZINES.	
The Engineering News	28
The Engineering Record	22
ENGRAVING.	
The Stoddard-Brown Co.	28
EXPANDED METAL.	
Eastern Expanded Metal Co.	14
The Warner-Miller Co.	35
FIREPROOFING.	
William H. Brodie Co., New York, N. Y.	7
FLUSH TANK.	
Pacific Flush Tank Co., Chicago, Ill.	37

IRON, STEEL, ETC.	
Berlin Construction Co., Berlin, Conn.	(back cover)
PAINT.	
Detroit Graphite Manufacturing Co., Boston, Mass.	11
Joseph Dixon Crucible Co., Jersey City, N. J.	9
PAVEMENTS.	
The Hartford Paving & Construction Co., Hartford, Conn.	15
The New York Brick & Paving Co., Syracuse, N. Y.	25
Warren Bros. Co., Boston, Mass.	35
PRINTERS.	
The Tuttle, Morehouse & Taylor Co., New Haven, Conn.	21
PUBLISHERS.	
S. E. Hendricks Co., New York, N. Y.	16
The Engineering News	28
The Engineering Record	22
PUMPS.	
Edson Manufacturing Co., Boston, Mass.	12
RAILS.	
Harrington, Robinson & Co., Boston, Mass.	10
The Lorain Steel Co., Philadelphia, Pa.	24
RAIL JOINTS.	
The Rail Joint Co.	27
ROAD ROLLERS.	
Buffalo Steam Roller Co., Buffalo, N. Y.	8
SANITARY ENGINEERS.	
Rudolph Hering and George W. Fuller, New York, N. Y.	17
SEWER CASTINGS.	
The Sessions Foundry Co., Bristol, Conn.	26
SEWER PIPE.	
American Sewer Pipe Co.	5
St. Marys Sewer Pipe Co., St. Marys, Pa.	30
The H. Wales Lines Co., Meriden, Conn.	20
The Warner-Miller Co., New Haven, Conn.	35
STEEL ROLLING DOORS.	
William H. Brodie Co., New York.	7
STONE.	
Connecticut Trap-Rock Quarries	32
C. W. Blakeslee & Sons.	33
The Warner-Miller Co., New Haven, Conn.	35
D. F. Keenan, Hartford, Conn.	19
The H. Wales Lines Co., Meriden, Conn.	20
TAPES.	
C. L. Berger & Sons, Boston, Mass.	22
George M. Eddy & Co., Brooklyn, N. Y.	13
W. & L. E. Gurley, Troy, N. Y.	(inside back cover)
Keuffel & Esser Co., New York, N. Y.	34
Kolesch & Co., New York, N. Y.	17
E. G. Soltmann, New York, N. Y.	22
The Lufkin Rule Co., Saginaw, Mich.	17
VALVES AND HYDRANTS.	
The Ludlow Valve Manufacturing Co., Troy, N. Y.	23

THESE Proceedings reach some 2500 engineers and contractors throughout the country. No like publication that we know of provides the same amount of advertising for so small an expenditure.

For rates and space, address

J. FREDERICK JACKSON,

Secretary, New Haven, Conn.

DO NOT FORGET OUR ADVERTISERS

THEY ARE ALL FIRST CLASS AND RELIABLE

PATRONIZE THOSE WHO PATRONIZE US

Please Mention this Publication in Addressing Them

Alpha Portland Cement

**THE RECOGNIZED
STANDARD
AMERICAN BRAND**

Alpha Portland Cement Co.

NEW ENGLAND DEPARTMENT

521 and 522 Board of Trade Building

BOSTON, MASS.

F. N. KINNEY, Manager

JOSEPH S. KEEN, JR.
President and General Manager

H. BAYARD HODGE
Secretary and Asst. Treasurer

GEORGE M. BUNTING
Vice President and Treasurer

WM. H. ROTH
Assistant Secretary

The American Pipe Manufacturing Company

Engineers and Contractors for Water Works

No. 112 NORTH BROAD ST.

PHILADELPHIA

J. W. LEDOUX, M. AM. SOC. C. E.
Chief Engineer

JAMES H. DAWES
Supt. of Construction

HAROLD PEROT KEEN
Supt. Operating Dept.

AMERICAN AND GERMAN

BEST MANUFACTURERS OF HIGH GRADE
IN THE WORLD. EXTRA QUALITY ALWAYS

ALSEN

NEW YORK GERMAN

THE SIDEWALK CEMENT

EVERY barrel of **ALSEN'S** guaranteed to exceed "Standard Specifications," adopted by A. S. C. E., A. S. T. M., A. R. E., etc. A medium slow-set cement has proven in practical tests, in all countries, most **durable** and **safe**.

Forced strength, like forced growth, is **dangerous** to ultimate results.

We supply **QUICK SET**, however, to special order for special work.

ALSEN'S is the **SAFEST** cement manufactured, as Analyses prove.

Every barrel passes boiling test before shipped.

Every barrel is matured.

The **Panama Canal Award** by Isthmian Commission, the 70,000 bbl. City of Rochester contract, the Key West extension, and many works of nearly equal importance, without a single rejection under most exhausted tests, substantiate every assertion made for this Portland

"CEMENT INSURANCE."

WRITE FOR PRICES
TO
American Sewer Pipe Company
PITTSBURG, PA.

Largest Manufacturers of Sewer Pipe in the
World, having FACTORIES located in
FIVE STATES, with the very
best Shipping Facilities



MANUFACTURERS OF
"STANDARD AKRON"
"OHIO RIVER VITRIFIED"
"GRANITE"

SEWER PIPE

Chimney Tops
Flue Lining Wall Coping
Agricultural Drain Tile
Fire Clay Fire Brick Paving Brick
Porter Blocks
and all Clay Products

We make a specialty of 27-in., 30-in., 33-in., 36-in.,
Standard and Double Strength Pipe
for Water Conduits and Culverts

THE STANDARD AMERICAN BRAND

ATLAS
PORTLAND
CEMENT

ALWAYS UNIFORM

Output for 1907, over 13,500,000 barrels

**Specified by all leading Architects and Engineers throughout
the country**

The Atlas Portland Cement Co.

30 Broad Street New York

Send for Book on Concrete Construction

FIRE PROTECTION ASSURED

"Surrounded by Fire Traps but not Afraid."

The accompanying illustration shows the **Connecticut Mutual Life Insurance Co's Building**, at Hartford, Ct.

which is equipped with

730 KINNEAR STEEL ROLLING SHUTTERS and

WILLIAM H. BRODIE CO.'S OPERATING DEVICE,

which operates these shutters in groups of 16, 18 and 24 shutters in 17 seconds, from the inside of building, at one time, without opening the windows.



Also in use in Car Barns, Factories, Warehouses, Pier Sheds, Power Plants, Dry Kilns, Round Houses, Elevator Openings, etc.

For Catalogue or further information apply to

WILLIAM H. BRODIE COMPANY

General Agents

45 VESEY STREET, NEW YORK CITY

BUFFALO PITTS



Asphalt Rollers
Macadam Rollers
Tandem Rollers
Combination Rollers
Golf Rollers
Improved Scarifiers

BUFFALO STEAM ROLLER CO.

EASTERN OFFICE

15 Court Square, Boston

150 Nassau St., New York

BUFFALO, N. Y.

Write for Catalogue

DIXON'S SILICA-GRAPHITE PAINT

THE FIRST GRAPHITE PAINT MADE

IT HAS ALWAYS BEEN FIRST
IN QUALITY AND DURABILITY

Interesting literature illustrating
the use of Dixon's Silica-Graphite
Paint on structural steel-work,
ornamental iron work and exte-
rior wood-work sent upon request

JOSEPH DIXON CRUCIBLE CO.
JERSEY CITY, N. J.

NEW ENGLAND OFFICE
101 Tremont St., Boston, Mass.

Wm. Wharton Jr. & Company,

—INCORPORATED—

PHILADELPHIA, PA.

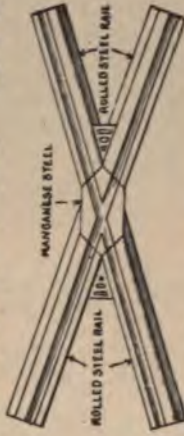
MANGANESE STEEL

THE ONLY MAKERS

—OF—

MANGANESE STEEL

Special Work.



POSITIVELY

THE

Longest Wearing

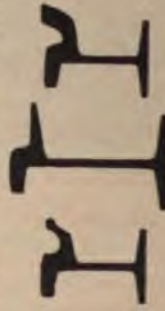
CONSEQUENTLY

THE

Cheapest to Buy.

THE BEST IN THE MARKET.

Rails and



Fastenings

New England Representatives: **Harrington, Robinson & Co.**

272-276 FRANKLIN ST., BOSTON, MASS.

Splice Bars, Track Bolts, Spikes, Trolley Brackets and Iron Trolley Poles. Designers and Builders STEEL BRIDGES. Roof Trusses and Steel Construction for Car Barns, Power Houses, etc.

TO Engineers, Architects, Manufacturers and others interested
in the preservation of Iron or Steel Structures from Corrosion

We will cheerfully furnish upon application an illustrated
Book, Showing Bridges and Buildings on which

Superior Graphite Paint

has been used

Interesting Tests and References are also given

It is hoped that prospective users of paint, not familiar with
this product, will investigate its merits before purchasing.
It is particularly adapted to withstand severe conditions.

Immediate Shipments made from Local Stock

Used on many bridges and buildings in Connecticut, to
which we would be glad to refer

Detroit Graphite Manufacturing Company

F. W. DAVIS, Jr., General Sales Agent

141 Broadway, New York 1117 Tremont Bldg., Boston, Mass.



Lift and Force Pump,
Nos. 8 and 10



Trench Pump, Nos. 2, 3 and 4

EDSON PUMPS

Edson Diaphragm Pumps are used all over the world for raising large quantities of water full of gravel, sewage, etc., by hand power.

The Trench Pumps are in use by fully twenty-five per cent. of the railroads and water works in the United States, and by a large proportion of the excavating contractors. This is an open discharge pump, made in three sizes.

The Lift and Force Pumps, also made in three sizes, used by prospectors and miners, for deep trench work, odorless excavating, pile sinking, and for forcing cement into quicksands, are well worthy of your consideration.

Edson Pumps are portable and non-chokable, pumping anything liquid enough to flow.

Send for booklets telling what they have done for others.

EDSON MANUFACTURING CO.

250 Atlantic Avenue, - Boston, Mass.

ESTABLISHED 1859

Warren Foundry & Machine Co.

ESTABLISHED 1856

Works at Phillipsburg, New Jersey

Sales Office, 170 Broadway, New York

Cast Iron, Water
and Gas

PIPE

From 3 to 60 in.
in diameter

Also all Sizes of Flanged Pipe
and Special Castings

GEORGE M. EDDY & CO.

345 to 353 Classon Avenue, Brooklyn, N. Y.

**COTTON TAPES
LINEN TAPES
STEEL TAPES**



Pioneers of the Tape Manufacturing Business in America

And the only firm giving its whole time and entire attention to the
manufacturing of tape measures

GEORGE P. BULLARD
President and Treasurer

GEORGE TAYLOR
General Manager

WM. M. BAILEY
Chief Engineer

CHESTER J. HOQUE
Constructing Engineer

EXPANDED METAL

THE APPROVED FORM OF STEEL
REINFORCEMENT FOR ALL KINDS
OF CONCRETE STRUCTURES, SUCH
AS SEWERS, BRIDGES, DAMS,
RETAINING WALLS, FOUNDATIONS,
WATER TANKS AND RESERVOIRS,
PEN STOCKS, FIREPROOF FLOORS,
∴ WALLS, PARTITIONS, ETC. ∴

Manufactured and Sold by the

EASTERN EXPANDED METAL CO.

Sixth Floor, Paddock Building

BOSTON, MASSACHUSETTS

**THE
HARTFORD PAVING
— *and* —
CONSTRUCTION CO.**

703 Main Street
Hartford, Connecticut

Concrete Arches *and* Foundations

PAVEMENTS

OF ALL KINDS

Artificial Stone Sidewalks

Masonry, Sewers

*Protect the Joints in your
Concrete with the*

HARTFORD WATERPROOF JOINT, patented

and insure good work

Established 1891 **350,000 Names and Addresses** Over 1,300 Pages

Issued Annually

Over 25,000 Classifications

THE SIXTEENTH ANNUAL EDITION OF

Hendrick's Commercial Register

OF THE UNITED STATES

For **BUYERS** and **SELLERS**

**Devoted to the Architectural, Electrical, Engineering, Iron
and Steel, Mechanical, Railroad and Kindred
industries of the United States**

This book is the most complete work of its kind ever issued. It includes all Professions and Trades interested directly or indirectly in the Mechanical, Electrical, Architectural, Engineering, Construction, Railroad, Iron, Steel, Machinery, Mill, Mining, and kindred trades.

In the lines we cover, every firm appears under its proper classifications, regardless of patronage.

It is invaluable to the Buyer or Seller, the Architect, Engineer, Contractor, Purchasing Agent, Manufacturer, Mine, Millman, Quarryman, Machine Shop, Boiler Shop, Rolling Mill, Foundry, Railroad, Electric Power and Lighting, Plantation, Ship Builder, Lumber Manufacturer or Dealer, Hardware Dealer, Planing Mill, and to every department of Municipal, State and National Government. There is not a Material, Specialty, Apparatus, or any kind of Machinery used in these vast industries under which the name and address of the Manufacturer does not appear properly classified. In fact, the work gives the name and address of the manufacturers of everything made from Iron, Steel, Brass, Bronze, Aluminum, Clay, Stone, Marble, Granite, Slate, Wood, Fiber, Asphalt, Asbestos, etc. In short, it enumerates every Finished Product manufactured from the above-named materials, not omitting the Professions that Specify, the Dealer who handles, the Manufacturers and Contractors who are consumers. This gives you in a nutshell the contents of our Commercial Register. It is bound in cloth and will be forwarded to any part of the country, expressage prepaid, on receipt of

PRICE, \$10.00

S. E. HENDRICKS COMPANY, Publishers

74 LAFAYETTE, CORNER FRANKLIN STREET, NEW YORK



LUFKIN
TAPES AND RULES
 ARE THE BEST IN THE WORLD.
 Made by **THE LUFKIN RULE CO**
 NEW YORK. Saginaw, Mich., U. S. A.
 LONDON. FOR SALE EVERYWHERE.
 SEND FOR CATALOG



HIGGINS'

DRAWING INKS
 ETHERAL WRITING INK
 ENGROSSING INK
 TAURINE MUCILAGE
 PHOTO MOUNTER
 DRAWING BOARD PASTE
 LIQUID PASTE
 OFFICE PASTE
 VEGETABLE GLUE, ETC.

ARE THE FINEST AND BEST GOODS OF THEIR KIND

Emancipate yourself from the use of corrosive and ill-smelling inks and adhesives and adopt the **Higgins Inks and Adhesives**. They will be a revelation to you. The Drawing Inks are the Standard of the World. Eternal Ink writes *everlastingly* black. The adhesives are clean, sweet and remarkably efficient. For home, office, library or school, for all private and public use we guarantee them absolutely **THE BEST**

AT DEALERS GENERALLY

CHAS. M. HIGGINS & CO., Mfrs.

BRANCHES: CHICAGO, LONDON.

271 NINTH STREET, BROOKLYN, N. Y.

Cable Address
 HYDOR, N. Y.

Lieber and Western Union Codes Used

Telephone Connection
 4980 CORTLANDT

RUDOLPH HERING and GEORGE W. FULLER
Hydraulic Engineers and Sanitary Experts

SPECIALTIES

WATER SUPPLY
 WATER PURIFICATION

SEWERAGE
 SEWAGE DISPOSAL

170 BROADWAY

NEW YORK

LEVELS AND TRANSITS
Engineers' Surveyors'
Supplies Outfits



WRITE FOR
 CATALOGUE O

SLIDE RULES
 5-8-10-15-20" in length

KOLESCH & CO. 138 FULTON ST., NEW YORK

“GIANT”

THE “OLD RELIABLE”

PORTLAND CEMENT

MANUFACTURED BY

The American Cement Company

Egypt, Pennsylvania

MORE THAN ONE MILLION BARRELS
USED ON THE RAPID TRANSIT SUBWAY

APPROVED AND USED BY PROMINENT ENGINEERS
ARCHITECTS AND CONTRACTORS IN THE MOST IM-
PORTANT WORK FOR THE PAST TWENTY-ONE YEARS

SALES AGENTS

LESLEY & TRINKLE CO.

604-610 Pennsylvania Bldg., Fifteenth and Chestnut Sts., Philadelphia

THE UNITED BUILDING MATERIAL CO.

320 Broadway, New York

101 Milk Street, Boston, Mass.

D. F. KEENAN

Crushed Trap Rock

For MACADAM, BALLAST
CONCRETE DRIVEWAYS
===== ETC. =====

ough Wall Stone and Bottom Stone Very Cheap

Four Crushers at Work at Quarry Near Newington
800 Tons Daily Capacity

*Stone delivered by Electric Cars along all lines centering at Hartford
or dumped into carts at Bins rear of 173 State Street*

Telephone 1675

OFFICE: ROOM 21, WAVERLY BUILDING

1 Main Street - HARTFORD, CONN.

Represented by DON O'CONNOR

THE
Huttle, Morehouse & Taylor
Company

PRINTERS and BOOKBINDERS

123 Temple Street, corner of Crown
New Haven, Conn.

Office Devices and Loose Leaf Work

STATIONERY DEPARTMENT

183 Crown Street

Best Lines of Stationery. Engraving and Steel Die Work

The H. Wales Lines Co.

MERIDEN, CONN.

DISTRIBUTOR OF

**DEXTER
PORTLAND CEMENT**

Ulster County Rosendale Cement

VITRIFIED SALT-GLAZED SEWER PIPE

A full line of all sizes and fittings in stock for prompt delivery

BLUE STONE

PILING

GRANITE

Builders' and Contractors' Material

THE
Tuttle, Morehouse & Taylor
Company

PRINTERS and BOOKBINDERS

123 Temple Street, corner of Crown
New Haven, Conn.

Office Devices and Loose Leaf Work

STATIONERY DEPARTMENT

183 Crown Street

Best Lines of Stationery. Engraving and Steel Die Work



C. L. BERGER & SONS

SUCCESSORS TO BUFF & BERGER

37 William Street BOSTON, MASS.

SPECIALTIES

Surveying Instruments of Precision

ALL KINDS

ALL SIZES

Catalog on Application

THE ENGINEERING RECORD

is the most progressive journal in the world devoted to civil engineering and allied industries. Since it passed into the control of the McGraw Publishing Co., some four years ago, its growth in size, circulation and influence has been phenomenal.

During 1906 it published more paid proposal advertisements than any other engineering paper.

Its contracting news service is noteworthy for its completeness, promptness and accuracy.

The subscription price is \$3.00 per annum. Sample copies on application.

PUBLICATION OFFICE

114 Liberty Street NEW YORK



E. G. SOLTSMANN

125 E. 42d St., New York, N.Y. SEND FOR PRICE LIST
Next to Grand Central Station

Continuous Prints made from
PROFILES

drawn on transparent Profile or
Cross Section Tracing Paper

PRICES for Large Prints up to $4\frac{1}{2}$ x 13 feet

BLACK	Prints on Paper, per sq. ft.	3c
"	" " Cloth, " " "	5c
BLUE	" " Paper, " " "	2c

DRAWING MATERIALS

BLUE PRINT PAPER

MENTION THIS PUBLICATION

LUDLOW GATE VALVES

ALL SIZES

ALSO

CHECK VALVES

FOOT VALVES

SLUICE GATES

FIRE HYDRANTS

ETC.

BEWARE
OF
IMITATIONS

We also make both electrically and hydraulically operated gate valves and sluice gates. Will cheerfully furnish estimates and designs on application.



ONE OF OUR LARGE ONES

GENUINE

LUDLOW GATE VALVES AND FIRE HYDRANTS

are made only by us and only in Troy, N. Y. They
have the words "LUDLOW, TROY, N. Y.," cast on them

NONE GENUINE UNLESS SO MARKED

THE LUDLOW VALVE MFG. CO. TROY, N. Y.

The Lorain Steel Company

Girder Rails

High Tee Rails

High-Grade

Special Track Work

And Electrically Welded Joints

General Offices

Pennsylvania Building

Philadelphia, Pa.

Also Offices at

New York, N. Y., 74 Broadway
Pittsburg, Pa., Frick Building
Atlanta, Ga., Equitable Building
San Francisco, Cal., Sixteenth and
Folsom Sts.

Chicago, Ill., Monadnock Block
St. Louis, Mo., Chemical Building
Cleveland, Ohio, Rockefeller Building
Philadelphia, Pa., Pennsylvania
Building

JOHNSTOWN, PA.

The Celebrated Syracuse Vitrified Paving Brick

MANUFACTURED AT

SYRACUSE, NEW YORK

Eastern References: New Haven, Conn., and Springfield, Mass.

DEPARTMENT OF PUBLIC WORKS

Engineer's Office, Room 17, City Hall

New Haven, Conn., May 1, 1907.

*The New York Brick and Paving Co.,
Syracuse, N. Y.*

Gentlemen: The following streets or portions of streets, in this city, have been paved with "Syracuse" Brick:

In 1892.	York St. (one side), bet. Chapel and Elm Sts.,	633.3 sq. yds.	Sand joints
In 1893.	Ashmun St., bet. Henry and Gregory Sts.,	2,432.1 " "	
In 1894.	Chapel St., at and near State St.,	947.6 " "	
In 1900.	Grand Av., bet. the Mill and Quinnipiac Rivers,	22,697.1 " "	
In 1900.	Commerce St., bet. Cong. Av. and Whiting St.,	2,708.5 " "	
In 1901.	Chapel St., bet. York and State Sts.,	13,491.8 " "	Grout joints
In 1901.	Congress Av., bet. George and Temple Sts.,	4,206.0 " "	
In 1901.	Crown St., bet. State and Temple Sts.,	3,567.8 " "	
In 1901.	Elm St., bet. State and York Sts.,	12,377.2 " "	
In 1901.	George St., bet. State and Temple Sts.,	5,661.2 " "	
In 1901.	Temple St., bet. Elm St. and Congress Av.,	7,480.0 " "	
In 1902.	Olive St., bet. State and Water Sts.,	10,341.0 " "	
Total		87,546.7 " "	

In 1896-7 about seven miles of "Syracuse" brick gutters for macadam and asphalt pavements were laid. During the year 1902, 545,000 "Syracuse" brick were purchased by the city for repairing pavements not originally laid with "Syracuse" brick. None of the above-named localities has been repaired excepting where the pavement was torn up for a specific purpose. The above total area represents about four miles of streets.

Very truly yours,

HENRY J. KELLOGG,

Assistant City Engineer,

New Haven, Conn.

Test Borings==Exact Samples

CORE DRILL BORINGS FOUNDATION TESTS

FOUNDATIONS FOR HEAVY ENGINEERING STRUCTURES INVESTIGATED

Samples of all materials penetrated saved for record and inspection. Samples of sand, gravel, quicksand, clay, hardpan, etc., shown in same condition as it is from where it is taken.

CORE SAMPLES FROM ROCK

Samples from various strata of rock encountered for investigating the nature and extent of rock in new quarries, mines, etc. The actual stone is brought up for inspection.

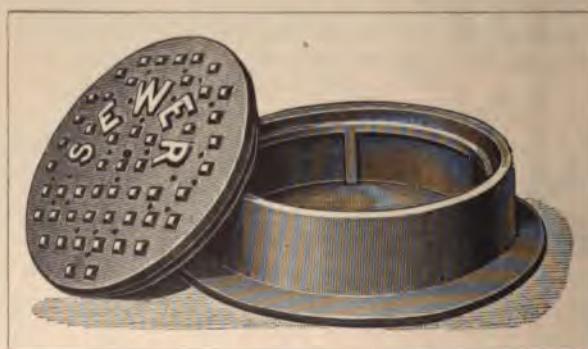
**Artesian Wells, Wind Mills, Pumps, Drilling Machinery, Well Supplies,
Elevated Tanks for Sprinkler System of Fire Protection**

C. L. GRANT

58 Belden St., Hartford, Conn. 17 Byron St., Providence, R. I.

The Sessions Foundry Co.

BRISTOL, CONNECTICUT



Low
Prices

**Sewer and Subway Manhole Castings
Sewer Catch Basin Castings, etc.**

To
Order

Prompt Shipments

Write us for estimates

Delivery at any point

Over 25,000 Miles in use

Showing the unprecedented approval of the
Base Supported Rail Joint by Railway Managers



Weber

MADE FROM
ROLLED STEEL
TO FIT OVER 125
SECTIONS OF
RAILS



Wolhaupter

Received the
Highest
Awards

Paris, 1900

Buffalo, 1901

St. Louis, 1904



Continuous Joint

Catalogs Furnished at All
SELLING AGENCIES

Atlanta, Ga.	New Orleans, La.
Baltimore, Md.	Pittsburg, Pa.
Boston, Mass.	Portland, Oregon
Chicago, Ill.	Seattle, Wash.
Cincinnati, Ohio	St. Louis, Mo.
Denver, Col.	St. Paul, Minn.
New York, N. Y.	Troy, N. Y.



Continuous

Protected by United States, Can-
ada and Mexico Patents

THE RAIL JOINT COMPANY

MAKERS OF

Continuous Weber and Wolhaupter Rail Joints

Step or Compromise and Insulating Joints

General Offices: 29 W. 34th St., New York City

YOU MAY CHOOSE THE BEST

Wants Situation Open 3 cents
Situation Wanted 1 1-2 cents
Miscellaneous 3 cents **A** Word
Word

The quickest and cheapest way to get the best technical help is by
using *Engineering News*

Engineering News

220 Broadway, New York

The Stoddard-Brown Co.

ENGRAVERS

66 CENTER STREET

NEW HAVEN, CONNECTICUT

SCHERZER ROLLING LIFT BRIDGES

are Modern, Scientific, Economical and Efficient, and are superseding and replacing swing bridges and other old and obsolete types of movable bridges for railroads, electric railways and highways in all parts of the World.



Scherzer Rolling Lift Bridge across West River, at Kimberly Avenue, New Haven, Conn.



Scherzer Rolling Lift Bridge across Newtown Creek, at Vernon Avenue, New York City.

More than 100 swing bridges have already been condemned, removed and replaced by modern SCHERZER ROLLING LIFT BRIDGES in Greater New York, Chicago, Boston, Cleveland, Buffalo, Saginaw, New Haven, and many other progressive cities in the United States and Abroad.

Highest Award World's Fair, St. Louis, 1904

Write us for Information, Photographs, Sketches and Estimates

THE SCHERZER ROLLING LIFT BRIDGE COMPANY

Main Offices: Monadnock Block, Chicago, U. S. A.

Cable Address
SCHERZER, CHICAGO

Eastern Office
220 BROADWAY, NEW YORK



5000 barrels of "WHITEHALL" Portland Cement used by D. L. Emanuel of Catasauqua, Pa., in the construction of the Dam on the Housatonic River for the New Milford Power Co., New Milford, Conn. Walter S. Morton, Chief Engineer for Power Co. "WHITEHALL" is made particularly for the trade that demands a Portland Cement of the highest quality.

The Whitehall Portland Cement Company

Principal Sales Office

1719-24 Land Title Building, PHILADELPHIA, PA.

Southern Office

Candler Bldg., Atlanta, Ga.

Eastern Office

141 Milk St., Boston, Mass.

The Edward Balf Company

26 STATE STREET, HARTFORD, CONN.

GENERAL TRUCKMEN AND CONTRACTORS

MOSLER SAFES DELIVERED

BUILDING STONE

CRUSHED STONE

SAND

GRADING

EXCAVATING

W. F. KEARNS COMPANY

161 Devonshire Street, Boston, Mass.

New England Agents

UNIT CONCRETE STEEL FRAME COMPANY

PHILADELPHIA, PA.

Manufacturers of the Unit System of Re-inforced Concrete

...AND...

THE GENERAL FIREPROOFING COMPANY

YOUNGSTOWN, OHIO

*Manufacturers of Expanded Metal, Metal Lathing, Metal
Furrings, Etc.*

Connecticut Trap-Rock Quarries

INCORPORATED

CRUSHED TRAP-ROCK
FOR BALLAST, MACADAM, CON-
CRETE, WALKS, DRIVES, ETC.

OFFICE

101 MEADOW STREET, NEW HAVEN, CONNECTICUT

Shipments by Rail to all points reached by The N. Y., N. H. & H. R. R. Co.

Daily Capacity of Crushers, 4,000 Tons

SMITH MIXER

THE SMITH is the most

**Efficient, Rapid
and Durable**

concrete mixer on the
market.

The great number in
use makes it easy to ob-
tain information con-
cerning it from contract-
ors throughout the Unit-
ed States.



Contractors' Supply and Equipment Co.

520 Old Colony Bldg, Chicago

170 Broadway, New York

C. W. Blakeslee

D. A. Blakeslee

Clarence Blakeslee

C. W. BLAKESLEE & SONS

58 Waverly Street, New Haven, Conn.

General Contractors

*Experts in Street Paving and
Macadam Road Making*

Steam and Electric Railroads, Dams, Sewers
and Heavy Masonry Built

Building Stone, Crushed Stone and Belgian Blocks Furnished

Keuffel & Esser Company

127 Fulton Street, New York

Branches: Chicago, St. Louis, San Francisco



Drawing Materials Surveying Instruments Measuring Tapes

We are the largest manufacturers of *Levels, Transits, Sextants, Compasses, Hand Levels, etc.* Our instruments are of most approved and advanced construction, and have many (patented) improvements.

All requisites for field and mine engineering.

All requisites for the Drafting room. Paragon, Key Brand and other Drawing Instruments.

Blue Print, Brown Print, Black Print Papers and Printing Apparatus, also for printing by Electric Light.

K & E Patent Adjustable Engine
Divided Slide Rules, 5, 8, 10, 16, 20 inch.



K & E Measuring Tapes

We manufacture Steel, Metallic, Linen, Cotton Tapes, Pocket Tapes, Band Chains, Flat Wire Tapes, Etc. *Most accurate. Largest assortment. The best.*

ALL GOODS WARRANTED.

Complete Catalog, 1906 (550 pages) on request.

*Highest } Grand Prize, St. Louis, 1904
Awards } Gold Medal, Portland, 1905*

EXPANDED METAL

AND TWISTED STEEL RODS

FOR REINFORCING CONCRETE

**ATLAS AND GIANT
PORTLAND CEMENTS**

SEWER PIPE



BLUESTONE

**EXPANDED STEEL LATH
PAVING BRICK**

**PROMPT DELIVERIES MADE FROM STOCK AT
NEW HAVEN**

FRANK OBERKIRCH, *President*

GEORGE C. SIMONS, *Sec'y and Treas.*



St. Marys Sewer Pipe Co.

*Sewer Pipe, Flue Linings
and all other clay products*

St. Marys, Pa.

Long Distance Exports



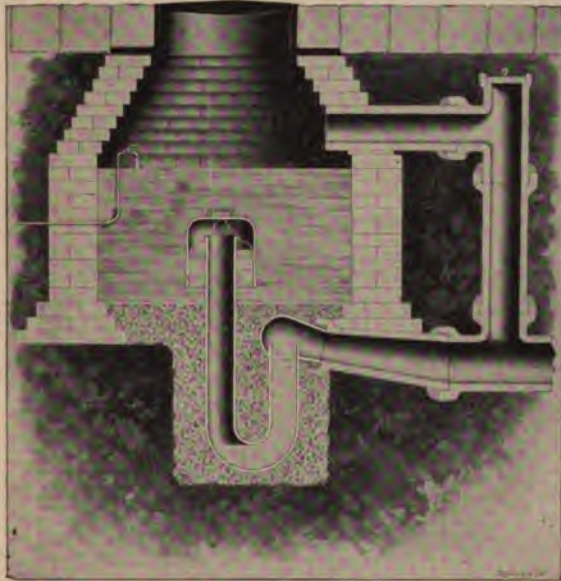
PACIFIC FLUSH TANK COMPANY

84 LA SALLE STREET, CHICAGO, ILL.

Manufacturers of the

Miller Automatic Siphon

FOR INTERMITTENT FLUSH TANKS



Used for Flushing Street Sewers

No Moving Parts

No Joints

No Little Traps

*Received the Highest Award in its Class at the World's Columbian Exposition
for Simplicity of Construction, Effectiveness and Reliability*

NEW HAVEN, CONN., March 1st, 1907.

The sewage filtration plant for Springside Home, New Haven, is equipped with an eight-inch special Miller Siphon, and has worked satisfactorily since put into operation, September 23, 1899.

(Signed) H. J. KELLOGG, C. E.

Each Siphon Guaranteed Absolutely

Send for Illustrated Catalogue

Paving a City Street

MAKES abutting property more readily salable at a higher price, and is an investment—not an expense. Pave with Bitulithic and you increase the value of your investment, and provide a Dustless, Noiseless, Sanitary and Durable street. One hundred and fifty cities have tried Bitulithic and have pronounced it the Best. Write for Comprehensive, Convincing and Interesting literature.

WARREN BROTHERS COMPANY

Number 93 Federal Street : Boston, Massachusetts

REGISTERED TRADE MARKS

"Bitulithic" "Puritan" "Bitrock" "Bituminous Macadam" "Bitustone"

ESTABLISHED 1845

INCORPORATED 1900

W. & L. E. GURLEY

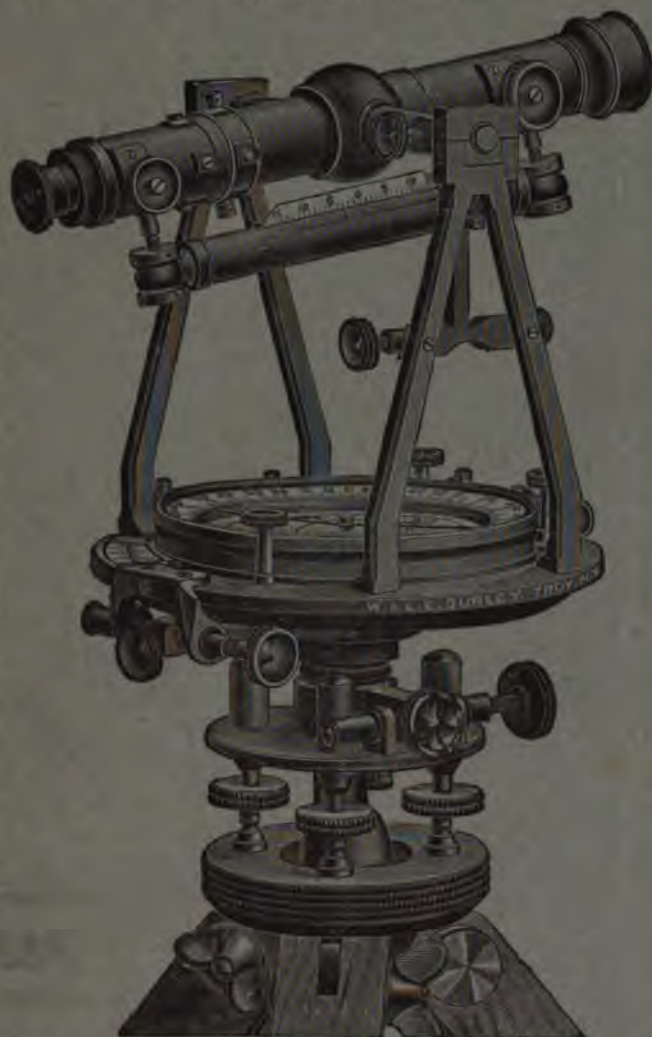
TROY, NEW YORK

LARGEST MANUFACTURERS IN AMERICA OF

Civil Engineers' and Surveyors' Instruments

Y Levels, Compasses, Leveling Rods, Chains, Transits, Plane Tables,
Current Meters, etc.

Accurate Mercurial Thermometers, Barometers and Anemometers



Physical and Scientific Instruments, Standard Weights and Measures

Also Dealers in Tape Lines, Drawing Instruments, Paper, Colors,
Brushes, Protractors, Scales and Rules, Triangles,
Curves, Pocket Compasses, Magnifiers,
Telescopes and Field Glasses

Illustrated Catalogues mailed on application

D. E. BRADLEY
President

GEORGE H. SAGE
Vice President

SEYMOUR N. ROBINSON
Treasurer

Berlin Construction Company

STEEL BUILDINGS, BRIDGES
AND STRUCTURAL WORK



STEEL-CONCRETE CONSTRUCTION A SPECIALTY

OFFICE AND WORKS: BERLIN, CONN.

220 Broadway
NEW YORK

131 State Street
BOSTON, MASS.

22 Clinton Street
NEWARK, N. J.

18 1909

CONNECTICUT SOCIETY
OF
CIVIL ENGINEERS



1908

VIA

Genuine Rosendale Cement



Used in the construction of nearly all the
Yale Buildings, New Haven, Conn.

Over one hundred miles of sewers in New Haven
were built with Rosendale

ONE PROMINENT ARCHITECT WRITES

"I have uniformly specified and insisted on your Cement, sometimes when others would have been easier to get, and have found it superior for floor work to Portland."

CONSOLIDATED ROSENDALE CEMENT CO.

GEO. G. GLEASON, Sales Agent

50 Church Street

New York City

24

✓
Connecticut
Society of Civil Engineers



Papers and Transactions for 1907

AND

Proceedings

OF THE

Twenty-Fourth Annual Meeting

AT

NEW HAVEN. FEBRUARY 11 AND 12, 1908

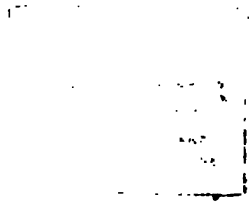


New Haven

THE TUTTLE, MOREHOUSE & TAYLOR COMPANY

1908

Ⓐ



Connecticut Society of Civil Engineers

ORGANIZED AT BRIDGEPORT, JANUARY 15, 1884



Officers for 1908

EDWARD W. BUSH, HARTFORD, ... *President*
FREDERICK J. EASTERBROOK, NEW HAVEN, *First Vice President*
FREDERICK H. OLDERSHAW, NEW BRITAIN, *Second Vice President*
J. FREDERICK JACKSON, NEW HAVEN, *Secretary and Treasurer*
CLINTON L. COLE, HARTFORD, ... *Assistant Secretary*

Directors

CHARLES F. CHASE, NEW BRITAIN.
HENRY J. KELLOGG, NEW HAVEN.
GEORGE K. CRANDALL, NEW LONDON.
JOHN K. PUNDERFORD, NEW HAVEN.

CONTENTS.

Purification of Water by Sand Filtration. By Wm. B. Fuller	1
State Boundary Survey. By Henry R. Buck	19
Stream Flow Data with Reference to Water Power in Connecticut and Vicinity. By Charles E. Chandler	37
Discussion	66
Meters and Water Consumption of the Hartford Water Works. By Ermon M. Peck	67
Reinforced Concrete Bridges. By M. W. Denman	70
Discussion	82
Harbor and Rivers of New Haven. By J. Frederick Jackson	94
Discussion	104
Hydraulic-Fill Dams. By Walter S. Morton	106
Discussion	114
Mill Rock Water Tower, New Haven, Conn. By Edward E. Minor	115
Discussion	119
"Snap Shots in American Cities." By Frederick L. Ford.....	120
In Memoriam.....	122
PROCEEDINGS:	
Report of Board of Direction	126
Secretary's and Treasurer's Reports	128
Special Committee Report	129
President's Address	133
Election of Officers	136
Constitution and By-Laws.....	139
List of Members	147

LIST OF EX-PRESIDENTS

WITH DATES OF SERVICE

B. HULL.....	1884, 1885
CHARLES M. JARVIS	1886
CHARLES E. CHANDLER	1887
CHARLES H. BUNCE	1888, 1889
F. FLOYD WELD.....	1890
E. P. AUGUR	1891, 1892, 1893, 1894
WM. G. SMITH	1895, 1896
ROBERT A. CAIRNS.....	1897, 1898
EDWIN D. GRAVES	1899, 1900
HENRY J. KELLOGG	1901
CLARENCE B. VORCE	1902
FREDERICK L. FORD.....	1903
JOHN K. PUNDERFORD.....	1904
ALBERT B. HILL.....	1905
CHARLES F. CHASE.....	1906
DANIEL S. BRINSMADE.....	1907

THE PURIFICATION OF WATER BY SAND FILTRATION.

WITH SPECIAL REFERENCE TO RECENT IMPROVEMENTS GREATLY
REDUCING BOTH CONSTRUCTION AND MAINTENANCE COSTS.

By William B. Fuller, Consulting Civil Engineer, New York City.

Historical Slow Sand Filters. It is seventy years since the first slow sand filter plant was put into operation in London, England. Similar filter plants have been in operation in Germany for fully fifty years and in the United States for over thirty years, and yet it has only been during the past ten years that much attention has been paid to the biological processes going on within such filters, and special efforts made in construction to utilize these processes in the obtaining of pure water. The first London filters were built as strainers to remove the grosser particles of mud and sediment present in the water, and while they were crudely constructed, regulated and operated, they fully served the purpose for which they were built. In Germany, early attention was given to the biological side and extensive studies made as to the best methods of construction and operation, and, as a result, ten years or so ago, Germany was far in advance in the science of purification of water by filtration. In this country, impetus into investigations relating to the purification of water was first supplied by the State Board of Health of Massachusetts, who, in 1887, began experiments in the purification of sewage and, about 1890, extended the scope of their inquiries to cover the purification of water as well.

This led, in 1893, to the building of the Lawrence, Mass., open slow sand filter,—the first filter in this country, built for the expressed purpose of reducing water-borne diseases by purifying the water supply. Its success was instant and very marked, but it was not until the building and placing in operation of the Albany filter, in 1898, that we can say that the principle of bacterial purification of water supplies was well recognized and the general type of slow sand filters in America well established.

Historical Mechanical Filters. In the meantime, about the year 1884, Mr. J. W. Hyatt patented a process of using a coagulant in the water before filtering, thus allowing a very high rate of filtration through much coarser sand than could be used in slow sand filtration.

While this method or process came into quite instant and general use by manufacturing plants desiring a clean water, its use for purifying drinking water was very limited until after the scientific side was thoroughly studied by Mr. George W. Fuller for the Louisville Water Company in 1895-97. The first filters to be actually put in service on these new lines were those put into operation at Little Falls, N. J., in 1902, for purifying the water supply of Paterson, N. J.

America now in the Lead. Since the building of the Albany filters in 1898 and the Little Falls filters in 1902, there has been built in this country a large and constantly increasing number of both types, each one improving on its predecessor in both construction and efficiency, until now it is well accepted that America is in the lead in such work, and those who wish to be up in the study of filtration plants and methods must make a careful study of the newer American plants.

Slow Sand Filters. The slow sand filter consists essentially of a water-tight tank, provided with sufficient drains to carry the filtered water to a single outlet. These drains are covered with a layer of broken stone or gravel and this gravel is again covered with several other gravel layers, the gravel stones of each layer decreasing in diameter until those in the top layer of gravel are of a diameter only equal to coarse sand. On top of the gravel layers is spread two to four feet of uniformly graded sand. The raw water enters the filter tank above the top of the sand layer and is generally kept four to six feet deep over the sand layer.

The raw water passes slowly downward through the sand layer until it reaches the gravel layers, where it freely flows through the gravel to the underdrains and thence to the clear well.

An essential to the successful obtaining of pure water by the operation of slow sand filters is as follows: First, that the raw water does not contain very large amounts of finely divided particles of mud or clay; second, that the sand layer is uniformly graded so that the flow of water through each unit of area is uniform and does not develop springs or breaks which would allow

of the direct passage of quantities of raw water direct to the underdrains; third, that the level of the raw water over the sand be kept at a uniform level during the run; fourth, that the rate of flow through the sand layer be kept at a uniform slow rate; fifth, that the supporting gravel be so graded that no particles of sand find their way downward into the underdrain.

Operation of Slow Sand Filter. The raw water passes slowly downward at a rate of about four inches per hour and as a consequence of the slow motion all the dirt has time to settle out on the surface, or very near the surface, of the sand layer, not generally over one-half an inch below, though sometimes it extends to one to two inches below. Entangled with the dirt are the bacteria of the water, both the harmless and the harmful, the former, however, in much the greater number. These bacteria mat themselves together in a somewhat gelatinous mass, to which has been applied the name "Schmutzdecke" as given by the Germans. The American word "slimes," as applied in gold-mining, seems to convey a very much better description of its characteristics.

Owing to the minute voids between the particles of the Schmutzdecke, all the bacteria and fine mud or turbidity is held back, the Schmutzdecke continues to grow thicker, the available head for forcing the water through the filter is quickly used up and after a few days the filter must be cleaned to be able to keep up the required quantity. The methods of cleaning and their results will be taken up later.

The Mechanical Filter. The mechanical filter consists essentially of a water-tight tank, provided at the bottom with outlet pipes of sufficient size to take the filtered water to the clear well. These pipes branch and sub-branch to all parts of the area of the bottom of the filter and are provided about every six inches with brass strainers, which let the water away from the gravel into the pipes without allowing any of the gravel or sand to pass in at the same time. The strainers are covered with a thin layer of gravel larger than the sand used for filtering and made of stone, having a higher specific gravity than that of which the sand is composed. Above the gravel is a layer of sand having a thickness of about three feet. The sand is uniformly graded as to size, but the grains are of a much greater diameter than that of the sand used in slow sand filters.

The raw water enters the filter above the top of the sand layer and passes downward through the sand and gravel into the strainer system and thence to the pipes, by which it is carried to one point and discharged into the clear well. The essentials to the successful obtaining of pure water from a mechanical filter are as follows: First, the application at all times, day and night, without a moment's interruption, of the proper amount of coagulant to the raw water; second, that the filter sand be of uniform size, the danger of breaks being greater than with slow sand filters; third, that the rate of flow of water through the sand be maintained at a uniform rate during the entire run; fourth, that the filter be watched to see that the turbidity does not work down through the sand layer before it is time to wash.

Operation of Mechanical Filters. The operation of the filter is similar to that of a slow sand filter; the coagulated water passes downward through the sand layer at a rate of about fourteen feet per hour, a rate too rapid to allow any of the bacteria to act biologically as in a slow sand filter, but still not so great but that the coagulated particles of dirt and bacteria are caught and held in the voids of the sand particles. That is, this process is essentially one of straining, and depends entirely on the coagulation of the material to be removed into an aggregate of large particles too large to pass the voids in the sand. The collecting of these coagulated particles in and upon the sand soon stops up the voids and a greater and greater head has to be used to force the water through the sand layers. When this head reaches a predetermined amount, the filter must be shut off and cleaned. The methods of cleaning and their results will be taken up later.

Loss of Head. It may be well to explain here a little more fully what is meant by loss of head.

When clear water passes through the voids in clean sand, the friction losses are the same as if the water passed through innumerable small crooked tubes; that is, if it takes a pressure of say two inches to force a given quantity through one foot of sand, it takes double this pressure to force the same quantity of water through two feet of sand. If, on the other hand, the depth of the sand remains the same and the voids are made smaller, the pressure to force the water through must increase inversely to the square of the average diameter of the voids; that is, if a certain quantity of water is being forced through a certain thickness of

sand by, say two inches of pressure, and if then the voids are reduced to half their former diameter by being partly closed with dirt and bacteria, it will take four times as much additional pressure, or eight inches, to force through an equal amount of water. This is the way that all filters operate. They are designed primarily to deliver a certain quantity of water during a certain period of time and all modern filters are equipped with regulators or controllers which change the head or pressure on the sand layer so that the discharge shall be uniform at all times.

It is seen that provision must be made, in establishing a filter plant, for the pressure necessary to force the required amount of water through the dirty sand layer and in addition, of course, through the necessary piping of the filters. This head varies much under local conditions, but ordinarily it is assumed from four to seven feet for slow sand filters and from eight to fourteen feet for mechanical filters. When a filter is placed in an existing gravity supply, the loss of head or cutting down of pressure of the supply is always a serious matter and should receive much study so as to make it a minimum consistent with good service. Where it is necessary to pump, the addition of a few feet loss of head more or less does not make any appreciable difference.

Comparison of the Two Types. It is seen that there are many points of resemblance between the slow sand and mechanical types of filters and it is often, especially in the Eastern States, that only a very close comparative estimate of original construction cost and costs of maintenance will decide the best type to use in a given case. The slow sand filter is especially adapted for the purification of water relatively high in bacteria or algae and not containing any high periods of turbidity. The mechanical filter, on the other hand, is adaptable to all conditions of water and at all times produces a clear and sparkling effluent, much appreciated by consumers of water irrespective of its purification.

If absolute reliability in the application of changing quantities of coagulant to the changing conditions of the water could always be secured, this would become the ideal system.

Controllers. In either system good results cannot be obtained unless a uniform quantity of water passes through the filters in a given unit of time. On account of the continuously changing head, caused by the collection of dirt in the voids of the sand as previously explained, this is a rather difficult matter to control,

and a great many weirs, regulators and controllers, some automatic and others not, have been invented and used on the various filters constructed. Indeed, this is the one matter that is not yet down to a standard and on which the individual engineer continues to exercise his ingenuity and preference. At the Albany slow sand filters, the regulation is by means of submerged orifices controlled by hand; at New Haven and Washington it is by venturi meters controlled by hand; and at Philadelphia by automatic balanced weirs. The regulation at the Little Falls mechanical filters is accomplished by automatic submerged orifices, and at Hackensack by automatic balanced weirs; but the newer mechanical filters at Columbus and Cincinnati are controlled by enclosed balanced orifices working under pressure—and this seems to be the coming type of controller for both types of filters, as it has several advantages over any of the open types of controller.

Cleaning Sand. We now come to methods of cleaning the sand of the filters, as on these methods depend the efficiency of the whole plant, and it is in improvements in this line that there are very favorable indications towards a universal filter, that is, one which combines the advantages of both the slow sand and mechanical types at a much less cost than either.

The original method of cleaning slow sand filters, and one still in very general use, is to lower the water to below the level of the top of the sand and to scrape off the top of the sand to as great a depth as the dirt appears to have penetrated, loading the dirty sand into wheelbarrows and wheeling it into a court where it is stored until washed and replaced. This process goes on after each successive filter run until ultimately one and one-half to two feet of sand have been removed from the filter, when about six inches of the remaining sand is spaded up loosely and the washed sand from the court is wheeled back and the sand brought to its original level. This process requires a large amount of labor and holds a filter out of active service for many days, so it is not strange that endeavors have been made to decrease the labor and time out of service.

At Philadelphia and Washington, advantage is taken of the transporting power of water under pressure and the Schmutz-decke is shoveled into a portable hopper supplied with water under pressure. This water takes up the sand in suspension and

transports it through a series of pipes to a sand washer in the court, from which it is delivered nicely washed and cleansed to bins in the court. When the time comes for replacing the sand, it is put back in the filters by wheelbarrows or carts about as previously described. The next step in advance is typified by the method in use here at New Haven. One filter is kept continuously out of service and the sand is scraped, put into an ejector and transported to the sand washer as previously described. Instead of then being discharged into bins or piled up in open courts, it is again taken up by the pressure water and carried to a receiving basin in the filter out of service, from which place the dirty wash water flows away to the sewer and the clean sand is spread in the filter. When one filter is refilled, it is put in service and the receiving basin changed to another filter held out of service. This is an ideal way of handling the sand washing question and on a small filter plant like that at New Haven gives an air of neatness and order which is very sadly lacking about all other slow sand filter plants.

The next step has been essayed by the Pittsburg filter plant, where an attempt is to be made to do by machinery what has heretofore been done by hand labor. This plant is not in running order, as yet, but the apparatus is all purchased and in place and ready to run.

Instead of men scraping up the Schmutzdecke and throwing it into an ejector, this work is done by a scraping machine rolling along on rails supported by the piers and operated by electricity, one man operating the machine and gauging the depth of cut and the speed of travel; the dirty sand is automatically fed to an ejector and carried to the sand washer by water under pressure, and from there to a filter out of service, as described for New Haven. The receiver, however, in the Pittsburg case is an elaborate affair operated by electricity and is so arranged that as the sand and water enters, the water overflows to a sewer, while the sand is dredged up and conveyed to special conveyors which spread the sand in a uniform layer as the machine travels ahead.

Draining and Refilling. Preliminary and subsequent to the scraping and cleaning operations, as outlined above for slow sand filters, it is necessary first to drain the water off the bed. This is usually done by shutting off the raw water inlet and allowing the

water left in the filter to filter through the sand. On account of the constantly decreasing head, the rate of filtration becomes slower and slower and it generally takes twelve hours for all the water to disappear. If in a greater hurry, valves above the sand line can be opened and this water run to waste. On account of the cost and general scarcity of water at most plants, this is rarely done, however.

After the filter is scraped and cleaned and ready to be put into service, it must be refilled up to the high water line. On account of the water being drawn below the sand level during scraping, it becomes necessary to refill from below until the water reaches above the sand layer, so as to drive all the air out of the filter sand as the water rises. Filtered water has to be used for this purpose in order not to contaminate the underdrains, and suitable piping is generally provided to take this water from an adjacent filter. It is necessary that this refilling with filtered water take place very slowly, otherwise pockets of air will form which will seriously interfere with the regularity of the rate of filtration of the next run. Ordinarily about six or eight hours are allowed for this operation. After the refilling, the filter is started on its run, but it cannot be started at full rate at first, as the Schmutzdecke and great numbers of the nitrifying bacteria have been removed in the process of scraping and it is necessary for some time to elapse before a new Schmutzdecke can be started. It is therefore customary to start a filter at about one-sixth its full rate, increasing the rate by one-sixth additional about every twelve hours, taking, therefore, about three whole days before the filter reaches its normal rate and really constituting a delay of about one and one-half days to charge against the full operation of the filter.

Cleaning Mechanical Filters. The cleaning of a mechanical filter has reached standard practice and is much more simple than as above described for slow sand filters.

When ready to be cleaned, the raw water supply pipe and the effluent pipe to the clear water well are closed and filtered water is pumped at a rapid rate backward through the pipes and upward through the strainer system through the sand; this scours all the dirt from the sand no matter how deeply the dirt has penetrated, and it floats upward with the water and is carried off to a sewer. Ten or fifteen minutes of this reverse current is sufficient to

remove most of the dirt and allow of the filter to be started in its usual way. On account of the relative small amount of water on top of the sand, this is generally wasted with the wash water, and on account of the coagulated particles being so large that they will not pass the sand voids even when the sand is clean, it is not necessary to start the filter at slow rates, but it may be started at full rates at once. It is necessary, however, to use filtered water for the entire operation of washing, and as this amounts to about three per cent. of the entire supply, it is usually quite an added cost to this type of filtration. This method of cleaning the sand is very rapid, however, as the entire operation scarcely required more than fifteen minutes.

Reserve Areas Due to Methods of Cleaning. We have, as outlined above, a very great difference in cleaning the sand in two types of filtration, and it is these different methods of cleaning which have kept the two types so distinct, as there appears to be a direct ratio between the rate of filtration and the time that can be allowed for cleaning. For example, we will assume that about seventy million gallons of water will pass a slow sand filter between cleanings when the filter is run at a rate of three million gallons per acre per day. That is, the filter would run about twenty-three days, then it must be cleaned, and we have twelve hours' draining, twelve hours' scraping and thirty-six hours' refilling, starting up and regaining full rate,—or two and one-half days lost, equal to $2.5/25.5$ or ten per cent. of the total time the filter is in use. This means that to obtain the required output it would be necessary to build ten per cent. more filter capacity than is really required. The example cited is very conservative, because most filter plants as constructed have allowed for fifteen per cent. out of service.

Assume now that there could be no improvement in the period between cleanings and it was otherwise possible to run the filter at a rate of nine million gallons per acre per day, three times the rate in the above example. We would have the filter running seventy-ninths, equal to say eight days, and then with two and one-half days lost in cleaning, the filter would be out of service $2.5/10.5$, equal to twenty per cent. of the time, and it would be necessary to construct twenty per cent. extra filters in order to keep up the required output. It is readily seen from the above examples that if any improvement in rate of filtration can be

affected, corresponding greater improvements must be made in the methods and time consumed in cleaning—otherwise the added cost of constructing additional filters to compensate for time out of service would more than offset the advantages gained by the higher rate. That such improvements are possible is shown by the mechanical filter method of washing, which is done so quickly that practically no reserve filter area is required. For example, with seventy million gallons per acre between cleanings, 120 million gallon rate per acre per day will take a run of seventwelfth days or fourteen hours; allowing one-quarter hour for cleaning, we have the reserve required at .25/14.25, or two per cent. This at once suggests a strainer system and method of washing for a slow sand filter similar to that of a mechanical filter, but the cost of a brass strainer system and of a proportionate amount of water as used in the mechanical type absolutely prohibits its use with slow rates of filtration.

Other Methods of Cleaning. The problem as presented above was presented to the speaker about a year and a half ago in taking up the design of filters for the New York City Croton supply. From previous knowledge it appeared extremely probable that good bacterial purification could be obtained at as high a rate of filtration as ten million gallons per acre per day, and the problem resolved itself into obtaining a method of cleaning the sand which would not occupy over two hours per acre of surface and to design filters for this end. After careful consideration, two methods presented themselves as a solution. The first was a method of cleaning which had been in use for about a year previously on some open filters in Brooklyn. It consisted of lowering the water on the filter to be cleaned, to one inch of depth, and then, while opening an outlet to the sewer, to maintain a stream one inch deep over the surface, at the same time agitating the surface with rakes, thus stirring all the dirt from the top of the sand and having it carried away to the sewer. This process, as can be seen, was very simple and cheap, and offered great possibilities. The second process was presented by the Blaisdell Filtration Company of Los Angeles, Cal., who had patented and operated for some three years, at Yuma, Ariz., a machine which washed the sand in place in the filter without moving the water from the top of the sand.

Experimental Station. In view of the grave importance of the issues at stake, it was determined by those in authority to build

a small experimental filter and try out the two proposed methods of cleaning, as well as the ten million gallon per acre daily rate at which it was believed that Croton water could be filtered with good bacterial purification. This filter was built and has been running nearly a year, and without going into details, it may be stated that good bacterial purification of Croton water up to rates of ten million gallons per acre daily can be obtained without any question; indeed, the rate can be increased to twenty-five or thirty million gallons per acre daily without any material reduction in the bacterial purification obtained.

Brower Process of Washing. Washing the filters by the Brower process, that is, by the process as first described above as being used in Brooklyn, was also a success and is a process which can be used on a large scale with waters similar to the Croton, but it had the disadvantage of the loss of time due to lowering the water above the filter surface down to one inch and when the washing was finished, refilling again,—this taking too large a percentage of time when using high rates.

Blaisdell Washer. The other system of washing, called the Blaisdell system, has proved an unqualified success, and it is this system and the possibilities it opens up of combining the good points of both the slow sand and mechanical types at a much lower first cost and cost of maintenance than has been yet developed by either type separately, that I wish especially to call to your attention.

The Blaisdell washing machine is a product of the West, and is the outcome of a desire for clear water on the part of the small town of Yuma, Ariz. This town is on the Colorado River, whose waters are very turbid, practically all the time. Filtration of this water by slow sand filtration was manifestly out of the question, so the problem was turned over to one of the mechanical filter companies, who installed a plant which failed to improve the water and was abandoned. The Blaisdell Company then built and installed the first crude washing machine and it has been in operation for about four years, delivering clear water to the town of Yuma by clarifying a water heavily charged with mud, without the use of a coagulant and at a maintenance cost of almost nothing. At Yuma no attempt was made to ascertain the bacterial efficiency of the filtrate, the only desire being to get clear water, but the company, realizing the importance of demon-

strating this point as well as having an exhibition machine easily accessible and working on Eastern waters, offered to New York City to erect a machine at the experimental station, where its operations and the bacterial purification of the effluent water could be always under the eyes of the trained assistants in charge of the laboratory and station.



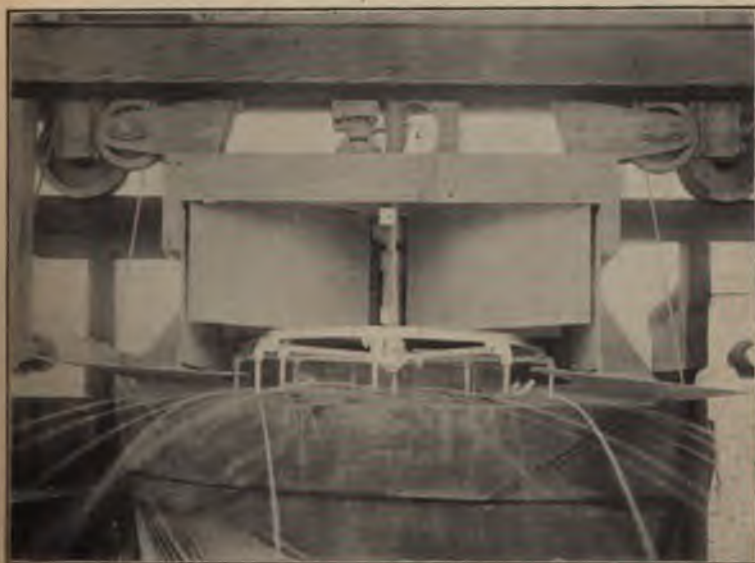
BLAISDELL FILTER SAND WASHING MACHINE AT YUMA, ARIZONA.

Showing first machine constructed for washing open filters. This machine has been in operation about four years.

The machine has been in operation about six months, sufficient to bring out many important points and to modify many of the ideas prevalent in regard to slow sand filters.

As has been said before, this machine washes the sand in place in the filter without removing the water from over the sand. There is therefore no delay in first draining the filter, but the washing can be done at any time, the only preparation being to shut down the effluent gate. On completing the washing, all that is necessary is to open the effluent gate and the filtration goes on as before. In this respect it resembles the methods of wash-

ing mechanical filters, and completely solves the questions of time out of service and percentage of reserve filters at high rates, for as many machines as necessary can be concentrated on the cleaning of any one filter so as to make the time of cleaning a negligible quantity instead of one of the most important elements in slow sand filtration as at present.



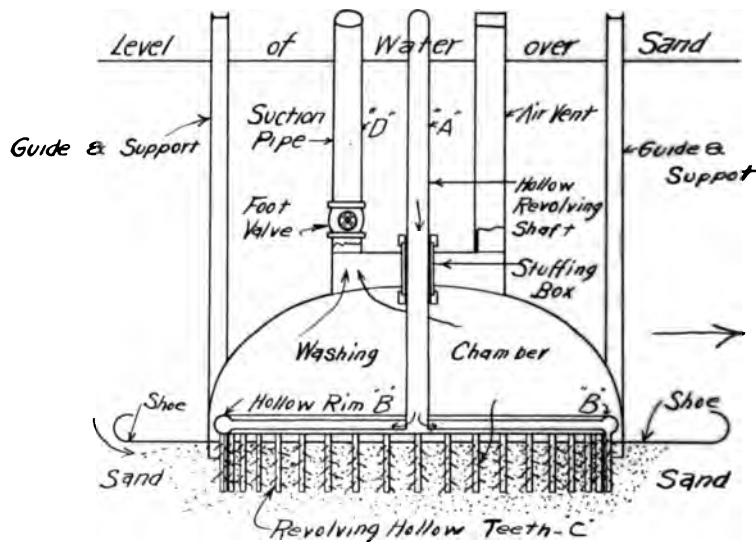
WASHING BOX OF FILTER-WASHING MACHINE.

With one side removed, showing revolving wheel and teeth, and wash-water entering through teeth.

The Blaisdell Washing Machine. The Blaisdell washing machine consists of an inverted open box about four feet square and two feet deep. This box is sunk under the water of the filter to the sand surface and is held in position and operated from a platform above, which platform is movable on rails supported by the piers of the filter. The box contains a revolving hollow axle and a hollow head from which hollow teeth project into the sand any desired distance.

By means of suitable electrically driven mechanism, all under the control of one operator, the box can be raised or lowered

and the platform can be moved forward or backward or sideways. By moving the platform the box is caused to slide over the surface of the sand at a speed of about ten feet per minute, while at the same time the hollow head and teeth are made to revolve slowly, stirring the sand mechanically. Water under a pressure of ten to twenty pounds per square inch is introduced



SKETCH SHOWING WASHING CHAMBER OF BLAISDELL FILTER SAND WASHING MACHINE.

Operation—The chamber being slowly moved ahead sliding on its shoes over the sand surface, water is forced through hollow shaft "A" to the hollow rim of the wheel "B" and thence to the hollow teeth "C" through fine perforations into the sand; the dirty water from the washed sand being drawn away from the washing chamber through suction pipe "D."

through the hollow axle, head and teeth and passes in strong, fine streams into the sand through fine holes in the teeth.

A suction pump connected with the top of the box is made to draw away just a little more water than is supplied through the teeth and thus carries away and discharges to a sewer all the dirt which has been stirred and washed from the sand.

On account of some water being drawn inward from the filter into the box under its edges through the sand to make up the

deficiency between the amount pumped out and that let in through the teeth, none of the dirty water escapes from the box into the filter, but is all carried away and discharged through a flexible hose into the sewer.



Filter with water drawn off showing clean sand after passage of washing machine and dirty sand on each side.

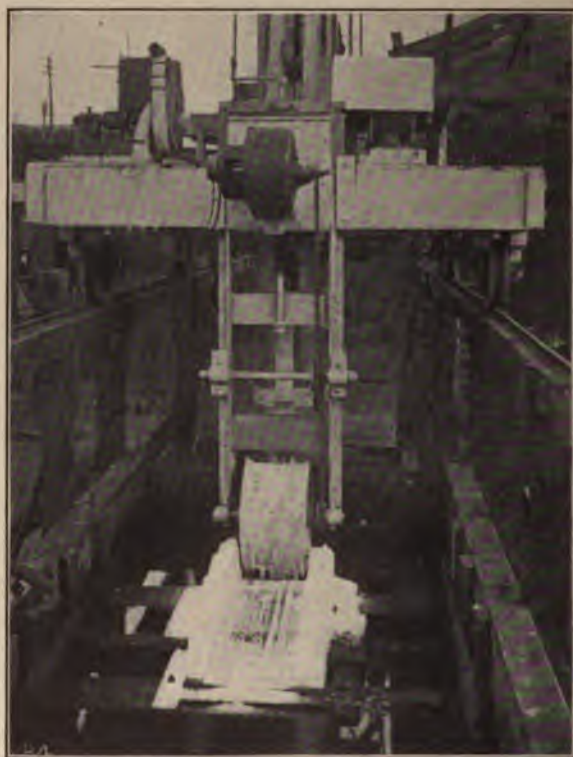
The box is slowly moved ahead over the sand and thus every part of the sand surface is gone over and cleaned, after which the machine is lifted from the filter and filtration started.

All of the operations of the machine are at all times easily under the control of one operator by simply throwing electrical switches.

The machine as installed at the Jerome Park Experiment Station is an entire redesign of the one at Yuma, having been designed, set up and operated by the company's Eastern representative, Mr. Geo. P. Baldwin, an eminent mechanical engineer,

through whose attention to minute details a thoroughly strong and serviceable machine has been constructed,—one which has worked right from the first day in service and by so doing has contributed greatly to the success of the experiments.

Uncovered filters. One of the advantages apparent with the Blaisdell machine is the possibility of using uncovered filters even



Showing method of cutting channel through ice for use in open filters during winter.

in cold climates, the machine working under the ice in winter. The box is supported and guided by two guides, one of which follows directly behind the other, so that by providing an ice cutter forward cutting a strip through the ice six inches wide, the box can be moved forward on the sand. Such an ice strip is easily cut by an electrically driven revolving cutter.

Effects of the Use of the Machine. The noticeable effects of the machine on the sand of the filter bed are as follows:

First, it removes all air from the bed. This is particularly noticeable as it is necessary to provide an air vent from the top of the box to above the water surface.

The removal of the air from the bed brings the entire area of the filter into active operation and produces uniform rates of filtration over the entire surface, results which it has been practically impossible to obtain previously in slow sand filters.

Second, it cleans the sand to any depth dependent on the length of teeth used. This prevents the gradual downward penetration of turbidity which ultimately shows itself in the filtrate in slow sand filters and shows how highly turbid waters can be filtered without the use of coagulents.

The turbidity is all caught and held by the new, clean sand, and with long teeth is all washed out before the next run, leaving new sand to store the mud as before.

In slow filters, some of the turbidity penetrates to below the depth of scraping, and all that does so is ultimately washed into the effluent.

Third, it hardens and settles the bed so that the voids between the sand become smaller, and the bed being more compact, is much less liable to contain veins or springs through which the raw water will reach the underdrains unfiltered.

Fourth, the tendency of the washing is to bring the fine particles of sand to the surface; this is where they are the most effective in holding back the turbidity and starting a Schmutzdecke.

Results of Tests. The removal of bacteria and turbidity have invariably been superior to any other method of cleaning, and this is so even immediately after cleaning, so there is not that necessity of starting up at slow rates to ripen the filter. There are certain methods of producing a thin Schmutzdecke directly to the rear of the machine which promise good bacterial results from the first start of the filter, but these have as yet not been worked out practically.

Results as Affecting Costs of Construction. The use of a Blaisdell washing machine, as outlined above, makes possible for the first time the use of comparatively high rates on slow sand filters, say from ten to thirty million gallons per acre per day.

This, of course, reduces the area of the filters necessary to construct for a given output to one-third to one-tenth of the area required for a slow sand filter, and this area does not necessarily have to be covered as the machine should work below the ice in winter as nearly as well as it works in the summer.

The cost of construction can therefore be brought to one-half to one-fifth that of the standard slow sand filter type.

Results as Affecting Maintenance Costs. The use of a Blaisdell washing machine, as outlined above, reduces greatly the cost of maintenance. Only one operator is required and as one machine can easily take care of five acres of filter surface, it is only in operation a very small part of the time on an ordinary sized filter. Less than five horse-power is required to run the machine under ordinary conditions.

The cost of operation even during periods of great turbidity should not exceed one dollar per million gallons.

Conclusions. It is believed that the washing machine, as described above, will so reduce costs that a large number of small water supplies which have been prohibited from filtering their supplies on account of cost, will be enabled to erect filter plants and filter their supply to the great benefit of communities dependent on them, and it is predicted that the development of this machine will advance the science of filter construction even more than has been the case in the past ten years.

Nine slides were then shown, giving an idea of the construction and operation of the Blaisdell washing machine and, by way of contrast, the method of cleaning sand at Osaka, Japan.—Ed.

STATE BOUNDARY SURVEY.

By Henry R. Buck, Mem. Conn. Soc. C. E.

Since October 4, 1905, I have had the pleasure of being connected with the Connecticut State Boundary Line Commission as engineer in charge of the re-survey and marking of the Massachusetts-Connecticut state line. One of the most interesting of the many duties which came up in connection with this oldest and longest of the state's boundaries was the looking into the records for reasons for some of the irregularities which exist, and it occurs to me that a little of this history may be entertaining to you as well as a brief account of the field methods used in the actual survey.

Mr. C. W. Bowen, in his "Boundary Disputes of Connecticut," has paraphrased this history very accurately, and there is a wealth of unused material at the state capitols in both Hartford and Boston.

On account of the discoveries of the Cabots in 1494 and 1497, England claimed the right to govern all this part of the country. The rights of settlement in the land between New Jersey and the St. Lawrence were given in 1620 to the "Council of Plymouth for the affaires of New England." This council in 1627 sublet to John Endicott and others their rights in the territory from three miles north of the Merrimac River to three miles south of the Charles, and from sea to sea. This was the Massachusetts patent, later confirmed by Charles I, and the line then established three miles south of the Charles is the basis of the present northern boundary of the State of Connecticut.

The point where the line crossed the Connecticut River early became a matter of importance. The settlers maintained a fort at Fenwick, and though Springfield at first thought herself in Connecticut, and helped pay the expenses of this, she later refused to do so on the ground that she was within the limits of Massachusetts. Both parties of colonists claimed the right to settle and tax Westfield.

After some negotiations Massachusetts, without the concurrence of Connecticut, hired Nathaniel Woodward and Solomon Saffery to determine the line at the Connecticut River. They first established a point "three miles south of the river Charles" and found its latitude. Then traveling around through Providence and Hartford they took similar observations at Bissell's Ferry, which they said was also on the boundary line. As a matter of fact, it is fourteen miles south of it. They made another more harmful error in their starting point, because, instead of measuring south three miles from the river Charles they measured from Wrentham Pond, which is itself over four miles south of the Charles and a tributary to it. By their hog yoke quadrant, or whatever instrument they used, they determined the latitude of this point as 41-55, while it really is about 42-01.

Just how far the Massachusetts state authorities were knowingly responsible for this poor work is now of no importance. Probably Connecticut was to blame as well as they, for the fact that she was not represented in the survey. This fact alone has been the cause of disputes lasting nearly two hundred years, of a great permanent loss of valuable territory to Connecticut, and of feelings of interstate hostility which must have been of great harm to both sides. Engineers more than any other professional men know that the time to settle a dispute is before it arises, and that the only sure way to settle a boundary line is for both sides to agree to it on the ground. If both states had had engineers on the survey of 1642, it is inconceivable that such blunders could have been made. Although Connecticut protested against the line as then determined, she did nothing but protest, and as it was the only sort of survey in existence, it was partially accepted for over fifty years. The result may be seen by a glance at any map of the whole state. Wrentham Pond is north of the northeast corner of Rhode Island. A line from a point three miles south of this to Bissell's Ferry was the line to which Massachusetts claimed jurisdiction. It passes through the present town of Woodstock and as far south as Stafford Springs. Massachusetts settled and governed lands in North Woodstock and the whole of Enfield and Suffield, and collected taxes from them exactly as in any other part of the Commonwealth.

Towards the end of the seventeenth century the conflicting claims between Massachusetts and Connecticut settlers in Suffield

and Enfield became so acute that Connecticut determined to have the Woodward and Saffrey survey checked. Massachusetts was asked to join, but neglected to do so, and in 1695 John Butcher and William Whitney made latitude observations which agree fairly well with present results. Massachusetts objected strongly, saying that the old line had been established so long ago that it should not now be disturbed, and the conflict among the settlers continued. Several sets of commissioners were appointed and reported various plans for dodging the line around the disputed territory, but all failed to agree, and in 1709 memorials were sent by both states to their agents in England to ask Queen Anne to settle the boundary. Nothing whatever came of this; in fact, the appeal was never officially made to the Court. Both sides were fearful, perhaps, of the radical and arbitrary changes which a poorly-informed and only slightly interested monarch might make.

Finally, in 1713, Massachusetts and Connecticut each appointed commissioners with full power to decide all controversies. Samuel Partridge, John Pyncheon and William Dudley were commissioners for Massachusetts; William Pitkin and William Whiting for Connecticut. An instrument was signed July 13, 1713, whereby Connecticut agreed to accept the error in the starting point, and that instead of beginning three miles south of the Charles River, they should confirm Woodward and Saffrey's station three miles south of Wrentham Pond. Massachusetts agreed to call a due westerly line from this point the boundary line, stipulating, however, that they should not be asked to bound on it. They might show it on the maps as the true jurisdiction line, but if Massachusetts had settled any land lying south of it she was to continue to govern and collect taxes there. For this privilege of governing this settled land, which they admitted was in Connecticut, Massachusetts was to give Connecticut the equivalent, acre for acre, in other wild land further up the country, which Connecticut could settle and govern within the limits of Massachusetts, if she chose. This agreement was carried out, and Connecticut received 107,793 acres of the public land in western Massachusetts and New Hampshire, which she promptly sold to Boston individuals for \$2,274, and like a dutiful mother, gave the money to Yale College.

The survey by these commissioners, with the determination of the area governed by Massachusetts south of the line, was the

first attempt to run the boundary all the way across the state. As before, Massachusetts did the work, but this time they had thoroughly competent surveyors and coöperation by Connecticut. The old report says, in the rambling sentences of the day, that the commissioners, "having mett at Wrentham the 24th day of October last, to attend said service by the Help and assistance of Samuel Thaxter and John Chandler, Esqrs., Surveyors appointed by the aforesaid Gov. of Mass., and having with them some surveying instruments, which we used heretofore on such an occasion, and upon good proff and tryal, the line is found to vary nine degrees from the Meridian Line."

Connecticut was the first state in New England to survey her boundaries. The New York line was run in 1685, though it was changed in 1731, and the Rhode Island line in 1703. The value of accurate work had not appeared at that time, and it is doubtful if the instruments at hand would have enabled them to do any better. Not until David Ritterhouse ran the Massachusetts-New York line in 1787 was any really fine work done.

Between the 24th of October and November 6, 1713, when the completed plan and report was signed, Chandler and Thaxter ran the line from Wrentham Pond east of the northeast corner of Rhode Island to the Connecticut River and around Enfield, at that time a town six by ten miles square. There is no evidence that they chained more than the twenty-two miles around Enfield, but they "erected sundry heaps of stones," and if they remembered the Sabbath day to keep it holy they accomplished the running of eighty-eight miles of line in not over eleven working days! No wonder the line is crooked!

The next spring, between May 25 and June 2, they surveyed the towns from the river west of the present east line of Granville and determined the area cut off by the new line. On the basis of this survey the settlement of the equivalent lands was made.

In 1717 by authority of a new act the same surveyors, Chandler and Thaxter, with a third commissioner, representing Massachusetts, and William Whiting of the former commission with two others from Connecticut, ran the line from the northeast corner of Southwick Jog to Sage's Ravine. They marked many trees, most of them on the banks of the streams, as the country was almost wholly a wilderness at that time and there were no roads.

For some reason, Dr. Hoadly reprinted the report on this one section of the line at the end of Vol. 1 and 2 of the Private Laws of Connecticut and you will find it quite interesting reading. They met at Westfield, September 12, ran the whole thirty-two miles and returned to Westfield in time to draw up and sign their report eight days later.

In Hartland on September 13 they had bad luck, for after they had run two miles and a half they say (this is in the act passed by the legislature), "We continued the line from thence two miles and a half and twenty perch, which brought us to a miry swamp of eight perch wide, and encamped, the weather wet; we had a very tedious night. At this place we marked a large hemlock, and called it Thaxter's tree."

West of the "Ousatonic" River they slighted the work a little, for they left the line in the middle of Sage's Ravine "in the gutter at a right angle from the north mountain, and incapable to have a monument made at it," and they called the distance only two miles from the river, while it is 4.7. Their distance to the Housatonic, 28.33 miles, is 1.02 too great, an error of 3.6 per cent., and something gradually drew their line north so that the boulder in Sage's Ravine is about $1\frac{3}{4}$ miles farther north than the northeast corner of the state. The present boundary follows their survey except in two places, so that if their work had been accurate and the line had been run due west along the parallel of 42 deg. 1 min. 24.807 sec. north latitude, the state line would now run through the railroad depot at Canaan.

This new Connecticut-Massachusetts line was perambulated in 1734 by a joint commission who determined the northeast corner of the state and pushed the line west to the present northwest corner. They ran also around Woodstock, which was then a Massachusetts town, and found a bad jog at the Union-Woodstock corner. A special commission investigated this in 1739 but did not change it. Somers and Enfield had asked in 1724 to be taken into Connecticut but had been told that the agreement of 1713 was binding, and the people generally considered the line as settled by the running of 1713.

The taxes in Massachusetts, however, were becoming larger than those across the line and the people in Woodstock began to wonder whether the jurisdiction could not be changed so as to put them on the cheap side of the line. In 1747 accordingly, they sent

a memorial to the Connecticut legislature asking to be considered a part of that state. They argued that the agreement of 1713 was not legal; that the legislature of Connecticut had no power to give away land which had been granted to them by the King and had no power to allow another state to govern land inside their colonial limits, and that the agreement had never been sanctioned by the King and was not binding. This time the townspeople were quite importunate, the attorney-general backed them up with an opinion in their favor, and the legislature, with everything to gain and nothing to lose, finally said, "Come in." Woodstock promptly had a jubilation meeting and elected delegates to the Connecticut legislature. Massachusetts, of course, was indignant and sent all kinds of remonstrances. Connecticut did nothing. She did not see how Massachusetts could expect to govern land which was admittedly outside of her colonial limits. Massachusetts wanted to arbitrate, but Connecticut said there was nothing to arbitrate. There even seems to have been some violence connected with Massachusetts' attempts to collect taxes. About this time, too, Rhode Island took notice and joined Connecticut in a survey at Wrentham Pond, where they found that Woodward and Saffrey's station was 7 m. 56 rd. south of the southernmost part of the Charles River instead of three miles, and that the north lines of both states should therefore be pushed north over four miles. This point appears more strongly if you glance at the present north line of Massachusetts, which was described as being three miles north of the Merrimac River in exactly the same words in which their southern line was described as three miles south of the Charles River. The farmers in New Hampshire claimed and held land very much further south than the most northerly point of the Merrimac, giving Massachusetts only a strip three miles wide, parallel with the river.

Connecticut now sent memorials to the old country and Massachusetts also fully informed her agents, but the royal attorney-general did not think it at all likely the Crown would be willing to change the agreement of 1713 and the appeal was never pushed. The matter was not really settled for 75 years, and Massachusetts continued for a long time to levy taxes and to go through a number of forms in relation to Woodstock, Enfield and Suffield, as if they were still within her limits. The people, however, called themselves in Connecticut and went by the monu-

ments made by the surveyors of 1713, except where they erected new monuments at more convenient points.

West of the river there was little settlement close to the line and the boundary question did not become a matter of legal controversy excepting at Southwick. This queer little notch which the schoolboy always puts in his map, even if he omits the Housatonic River, is the sole survivor of the equivalent lands which Massachusetts so long governed south of her south line. The land is quite good, there is some six square miles of it, and the Congamond Ponds are beautiful, yielding also a good crop of ice in winter and fish always. It should be in Connecticut and the only use I ever heard for it was that it anchors the state of Massachusetts in place, and keeps it from slipping out of the map into the ocean. The land about the ponds was originally part of Westfield, was settled by Westfield people, and the inhabitants had little connection with Connecticut and did not petition the legislature to be taken away from Massachusetts as did the other towns to the east. The Revolution occurred at this time, and these little quarrels were gloriously sunk in the greater. There is a story that Connecticut tried to enforce militia service on an inhabitant of the Jog who refused on the ground that he lived in Massachusetts. It is a matter of record that about 1793 the controversy had become so acute that both states appointed commissioners to examine the line and especially to settle this particular dispute. They dissolved in 1801, however, not having been able to reach an agreement. Both commissions made long reports stating the history of the line to date, Connecticut claiming everything up to the line of 1713, and Massachusetts holding tenaciously to all land south of the line which she had not lost before the war. They claimed in fact that she had always governed the whole of the ancient town of Westfield and was then governing a strip of what is now West Suffield as deep as the Southwick Jog, about two and one-half miles, and extending about as far east of the ponds as the present Jog does to the west, that is, east to the ancient east line of Westfield at Rising Corners. Massachusetts had, indeed, proposed to compromise by giving up her claim to the land east of the ponds if Connecticut would be equally self-sacrificing in regard to the land to the west, but the Connecticut commissioners did not believe they had power to give away one inch of what their consciences told them was Connecticut soil.

The next legislature, however, appointed a new commission with the express understanding that this compromise should be arranged, and in 1803 the agreement was made, the survey was extended from the ponds west to New York, and the whole line mapped and marked. This is the last work that was done west of the river previous to 1906.

East of the river the dispute was more acrimonious, perhaps, because the amount of land in controversy was much smaller.

The commission of 1734 had found that the northeast corner of Woodstock was 126 rods north of the 1713 line, and the northeast corner of Union 100 rods too far north. In the Connecticut Valley, too, when Enfield and Suffield had come into Connecticut, their north boundaries had been taken as the state line. These were apparently established "without the aid of the compass" by measuring six miles north from the ancient south line of Springfield, and instead of running due west, the north boundary of Suffield was described as being square with the river. Both lines were marked only by trees, and apparently when a line tree disappeared the most interested neighbor chose its successor in the direction which best suited himself. The line had thus become astonishingly crooked and it never reached north as far as the 1713 line. After many failures to agree, and several surveys by the states independently, a joint commission finally reached a settlement in 1826.

The parties to this agreement gave Massachusetts all that part of Woodstock which lay north of the 1713 line and compromised at Union by running a line half way through the Jog. West of the northwest corner of Stafford, they followed substantially the old north line of Enfield, adopting a line which, while still crooked, was far straighter than anything that could have been drawn through the numerous points in that part of the valley which were reputed to be on the line. This settled, on paper at least, all the controversy between Massachusetts and Connecticut, and I find absolutely no action by Connecticut since 1826. The line was supposed to have been marked permanently. They seem, however, to have misused the word permanent as much as we do to-day when we speak of permanent asphalt pavement. Being left without attention, the boundary lines loosened at a great many points. An idea of what the 1803

commission considered would be a permanent mark may be gathered from the following brief extract from their description: "Now, therefore, know ye that the underwritten commissioners, having considered their respective power legal and sufficient . . . to the end that . . . all doubts and controversies may be finally settled, the boundary clearly accepted and harmony properly established on the most solid foundations . . . we began on the



OLD BOUNDARY STONE.

west bank of the Connecticut River between a small butternut tree, marked MC, standing on the south, and a small crooked white oak, marked M, standing on the north about two feet distant from each other." Perhaps someone fastened a rowboat to one of these trees and pulled it out. At any rate we could not identify them last summer.

None of the stones were over five feet long and most of them set three feet out of the ground, so that frost had heaved them out probably a number of times. The selectmen and owners of adjoining property had been very good about setting them up, but in a number of cases they had chosen better spots on

which to set them the second time, and this without regard to the line. In six cases we were able to find men who knew personally about the moving of the stones, as it had been done within a few years, and there is no doubt that many more of the stones had been shifted so long ago that the fact had been forgotten.

The Massachusetts Topographical Commission had for some time been at work on their other boundary lines, particularly the



NEW BOUNDARY STONE.

New York line, and in 1898, by authority of a special act of legislature, they perambulated their Connecticut boundary and found its very bad condition. After that they kept petitioning the Connecticut legislature for concurrent action, and in 1905 an act was passed making special provision for Connecticut's coöperation.

The present Boundary Commission consists of Governor Rollin S. Woodruff, Attorney-General M. M. Holcomb, and Mr. Frank C. Sumner of Hartford, though at the time the work was begun the first two *ex-officio* offices were filled by Hon. Henry

Roberts and Hon. Wm. A. King. They agreed with the Massachusetts Commission to first survey the line and find what the actual conditions and disputes were. In the fall of 1905, therefore, I went over the whole line with the Massachusetts field engineer, Mr. E. E. Pierce, who had perambulated part of it in 1898, and decided between which points we would run the random lines. We also did a little triangulation that fall at the east end of the line, so that we were already to start the field work the next spring.

Massachusetts has been unusually well triangulated; first Borden from 1832 to 1838 covered the whole state and tied in a number of points on the Connecticut line. The United States Coast Survey refigured much of his work and took other observations in connection with the state topographical survey. Then the town boundary work of the state Topographical Commission and its successor, the Harbor and Land Commission, has kept two parties since 1890 determining the angle points in their town lines and publishing the results in atlas form. The Harbor and Land Commission in fact had already triangulated down to the state line from Stafford to Southwick, and from Rhode Island to the middle of Southbridge, and could not publish their results until the uncertainties at these points were removed. Our first work, therefore, was to locate by triangulation all the supposed angles on the line. Mr. Pierce has spent most of his time since graduating from the Massachusetts Institute of Technology at this work and is a most expert observer, so the field triangulation was under his wing while I paid more attention to the traverse. Our latitude and longitude is derived from the main stations of the Massachusetts State Topographical Survey, all the figures connected with which are on file at the State House in Boston. There is just enough difference between their work and that of the Coast Survey to prevent their being used interchangeably, but as all the triangulation stations we used are well described, and as all the figures necessary to connect the Connecticut line with them are also filed at the Capitol in Hartford, this is no objection.

Having the true azimuth of the line between the northeast corner of Connecticut and the northwest corner of Rhode Island, and that between the former corner and a triangulation station east of Wallum Pond in Massachusetts, on April 10,

1906, we set up the transit over the northeast corner of Connecticut, turned the included angle and started south for Rhode Island. The transits were six-inch inverters with "X" cross hairs, and read to twenty seconds. A little of the work was done with a one-minute erector with vertical hairs, using special paper targets for the long sights, but it was not as rapid as the inverters.



TOPOGRAPHICAL BACKSIGHT.

All our work was from backsight, except where the lay of the land made it possible to see the next station. Such a point occurred on the first tangent, where, after we had run about a quarter of a mile through the woods, we saw the flag on a tall pole which stood over the Rhode Island corner. From there on, of course, we kept checking down from this foresight. We ran the line on stout wire brads, driving them into green hardwood

stakes cut on the spot. The stakes were from two to four feet long to keep the point from being masked by undergrowth. We used either brads one-sixteenth inch in diameter, or nails about twice as thick, depending on the distance we were likely to use the point, and always snapped an elastic band over a piece of white paper so that it projected up behind the brad. These made splendid backsights and we never used a rear rod on the whole survey. On the brow of a good hill we often set up a two by four scantling with alternate six-inch bands of white and black cheese cloth tacked around it. This made a signal good for two or three miles. When we needed to see farther we set up a 4 x 4 tripod signal twelve feet or more high. As the longest tangent we had to run was five and one-half miles, this was ample. All chaining was done from nail to nail of these stakes without the use of plumb bobs. At least every alternate stake was made a transit point, so that we could measure the vertical angle, and correct for slope of tape. By using 300 and 400-foot light wire tapes, this gave us 600 to 800-foot sights, which were as long as we needed to use.

We thought of using spring balances and correcting for pull and sag, as these tapes are standardized for a twelve-pound pull, supported, but on testing we found that the stretch of a twenty-five-pound pull was counterbalanced by the sag within a tenth or two, and as we had triangulation checks every few miles the precision of taping was of no importance. We read to hundredths, as it took no longer and made the men more careful, but corrected only for slope. The work agreed with the triangulation from exactly to a difference of four feet to the mile which we distributed uniformly along the tangent in figuring the adjusted stations of the new stones.

All tape measurements were checked by stadia, and the fences, streams, roads, and buildings were located in the same way for a distance of some 300 feet each side of the line.

The stadia readings usually agreed with the tape within one to three feet on shots 300 to 1,000 feet long. We read only to feet, using a thirteen-foot rod with a special marking which Mr. Pierce had been using on his work. It is easier and faster to read than any rod I have seen, as there are four black spots to the foot instead of five as in the common design. Single feet are read by taking the fifth part of a division—always an easy thing to do.

The parties consisted usually of a transitman, head chain, one or two rodmen, and up to three axemen, according to the timber and also according to the amount of help. Indeed, we had difficulty in getting choppers as we went along, as the farmers were all busy and snapped up laborers whenever they could get them.



No attempt was made to cut a sky-line, but we did clear a much wider path than is usual in farm surveying to be able to get at least 600-foot sights wherever the nature of the ground permitted. The alignment work was very good, coming out after a two or four mile tangent on the stone in many cases, and usually within two feet. We assumed that the lines were run straight and made proportional corrections in figuring the offset for new stones. After the first lines were finished we had a chance to check the work from summits in three of the long tangents, and could see no error whatever in the straightness.

If the surveys of 1713 and 1717 had been without errors, the boundary of to-day would have been an arc of a small circle running due west. Owing to compass irregularities, however, the line angled greatly away from this arc. On the re-establishment of the boundaries in 1803 and 1826, the surveyors had used all the old points they could identify and run straight lines between them on which they set their road stones. We ran these same lines, straight great arc circles between the angle points mentioned in the descriptions, but instead of finding the road stones on the tangents, we often found greater angles at them than at the angle points.

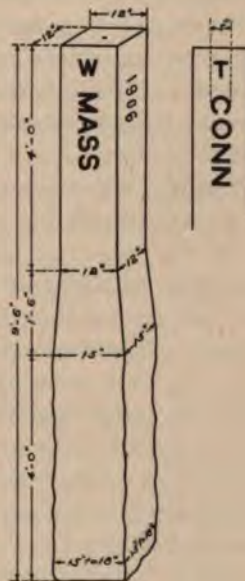
Our notes were sent in to the Boston office and plotted as fast as taken, so that in November we had the completed map of the line. On this we laid out a series of tangents which fitted as closely as possible all the indications of the boundary which we had been able to find. In many cases the markers at the angle points had been moved and we had to be governed more by the intermediate stones, but where the location of the old angle marks was unquestioned we always ran to them. The

line thus established was shown on the map, and after several visits to the ground and much discussion at three joint meetings, the commissioners agreed to it on December 26, 1906. It passes south of some stones and north of others, the offsets just about balancing. The greatest difference between it and the existing road stones was some sixty feet, but accepted unofficial monuments were as far off as 180 feet, and fences and trees locally supposed to be on the line were often much farther.

This year, from May to July, we set new granite monuments at every road and railroad crossing the line. The stones are nine to ten feet long, dressed twelve inches square for the first four feet, which part projects above the ground. The first fifteen inches underground is roughly pointed, and the stones batter out three inches in this distance, so that as the ground freezes it lifts always away from the stones and can never get a grip on them to pull them up. The butts are from fifteen to twenty-four inches square, rock faced, but with no projecting points, and the whole stone weighs from a ton to a ton and a half.

The lettering is "Conn" and "Mass" on opposite sides with the date "1906" on the face next the road and the initial of each town on the proper side. We also set twenty-two of these stones at the points where the town boundaries intersected the state line. These points are of great local interest and had been marked by local surveyors in every case but one, but by the most primitive of monuments. The railroad companies joined with us in setting eleven of these stones at their crossing points.

The old stones were all dug up and the good ones set on the summits between the roads. They were about five feet long and we left them projecting one foot, so that the drill hole in the top will make an ideal point to set up over if any engineer needs to re-run parts of the line. We have also made drill holes wherever good ledges were crossed.



The maps have been plotted on a scale of 1 to 3,000, or 250 feet to the inch. As the total length of the line is 94.8 miles, the map is some 160 feet long and will probably be folded into book form before filing with the Secretary of State at Hartford. Complete copies of the field notes and of the triangulation data will be filed with the State Librarian.

All the old stones as well as the new were photographed by the Harbor and Land Commission and a complete set of pictures will be filed with the notes. I have also taken photographs of houses cut by the line and additional views of various points of control which will make the collection complete. A set of mounted topographical sheets will show the triangulation net and all the stones on the line.

The only point which remains at all uncertain is the boundary along the shore of the Congamond Ponds. A natural boundary is always uncertain, but this was particularly so. The compromise of 1803 made the line "along the east shore of said pond as the same runs." Since then the water was raised to form the summit level of the Northampton Canal, then lowered to feed a mill in Granby, then dammed out of Connecticut by the mill owners of Westfield, who were in turn "damned" by the Connecticut farmers and compelled in court to turn back a part of the run-off, and now the water rises and falls in tune with a flash-board, manipulated by an agent of the writing paper trust.

To expect a state boundary to follow all these moves was too much. The Massachusetts Commission was unwilling to change the line to a series of tangents through the center of the ponds, but did agree that the shore line, "as it would be with surface of the water at the elevation it was in 1803," should be the boundary. We then described three bench marks which hold the level between one and three feet lower than at present. At one place, Pickerel Brook, the line cuts across outside of a swamp that is said to have been dry ground, though the water is more than three feet deep in places, but generally it follows the shore and is five to twenty-five feet out from it.

At Rising Corners is a jog of 132 feet. This is because the line of 1713 came eight rods south of an oak tree which marked the southwest corner of Springfield, now Agawam, and the 1803 compromise followed this line to the west and the old Springfield line to the east. The engineers of both states tried to have this

eliminated as the land changes could easily be balanced and were very small, but the Massachusetts Commission thought it had not sufficient authority to alter the line.

The actual running of the line was very interesting and we crossed some country about as wild as anything in New England. All the hills and highways run north and south, and in between the going is very rough, but only once were the party's headquarters out of touch by telephone. We had no great trouble in finding board within easy driving distance of the line, and in fact at our second headquarters the chief of the party was on the line day and night, for the boundary ran through his bed.

Most of the engineers were college men. At one time we had six graduates and four vacation men on the work, and all were very congenial fellows, so that much of the work was fun. The property owners were all interested and helped us greatly. We heard of several objections to the cutting after it was all over, but no one held us up or even attempted to hinder the work while it was going on. One man, who is interested in Connecticut politics, was greatly alarmed when he saw a line of stakes along the south side of his house, and he hurried to his selectman to see if he could not in some way avoid being shifted into Massachusetts. But it was only an offset line run to save us the trouble of chaining over his chimney.

One evening a lady who knew that the line ran through her house somewhere asked just exactly where it was, and she was not a little startled when I told her that the boundary ran right through her.

Twice the bulls bothered us. The first one was gentle and by scratching his head we kept him interested for a while, but he bellowed and tore up the turf so much that we finally ran the transit out of the pasture, until we had proved that a sufficient quantity of stone wall heaved at him from a safe distance seemed to blunt his interest.

The second bull was in the wilderness of Hartland, and the triangulation party was routed by him. They telephoned that he was a terrible fellow. They had good reason, too, for the farmers told them that he had gone wild soon after being turned out that spring, that no one had been able to enter the pasture since, and that the owner would have to shoot him in the fall. They said we had better come armed or he would kill us, sure.

I dug up a sixteen shot Winchester forty-four, and everyone of the party had something. I believe one man brought a thirty-eight calibre Savage tiger rifle. They were all unnecessary, however, for before using the guns the boys pelted him with sour apples;—and he turned tail and ran to the other side of the field.

We finished the field work October 29, 1906, at the Housatonic. One of the parties broke up in September when college opened; another came early in August but went back for a little while in October. Indeed the work was broken up all along, into sections which best fitted the condition of the triangulation, lack of axemen, etc. There were three rather bad choppers' cuts and never in the history of New England have there been so many hornets as we found in the summer of 1906; but the only serious accident we had was in locating the brook up Sage's Ravine, when the chief of the party slipped down a cliff and sprained his ankle. There was not a man sick all summer.

The spirit of coöperation and the consideration for the rights and ideas of the other party which was shown by everyone connected with the work from commissioner to chopper, was in sharp contrast to the bickerings which are spread upon the records of the earlier work on this line.

The only difference of opinion between the two states which has not been wholly harmonized is regarding the spelling which should appear on the map for the lake near the northeast corner of Connecticut. On our official plan it is simply Webster Lake. The maps of 1713, 1826, and 1887 substantially agree on Chaubunagungamaug, and one of the engineers thinks three g's are enough. Another, however, insists on 15 and writes it Chargoggagoggmanchauggagoggagungamaug.

STREAM FLOW DATA WITH REFERENCE TO WATER POWER IN CONNECTICUT AND VICINITY.

By Charles E. Chandler, Mem. Conn. Soc. C. E.

All those who are interested in the use, development or valuation of water supplies or water power, are interested in records of the flow of streams, as their future flow can be judged only by their past flow, or that of other streams.

The probable flow of any stream regarding which long-term records do not exist, depends on many things besides the area of its watershed, but the drainage area is the most important point, and must be made the basis and starting point of all estimates.

The value of stream flow data depends on: 1. The length of time during which the observations have been made. 2. The accuracy, frequency and precision of the measurements. 3. The form in which the data exists.

The greater length of time the flow of a given stream has been measured, the more surely the measurements indicate both the average flow at different seasons and the range of flows that have occurred and are likely to occur in that and similar streams.

For power purposes weekly or daily calculations are much more valuable than monthly calculations.

Data given in the form of second-feet per square mile are much more convenient for practical use in water power matters than when given in million gallons monthly or daily for the particular watershed observed. Data given in the form of available flow in second-feet per square mile every day, week or month, as the case may be, at all rates of development, has a still greater value.

The object of this paper is to present data covering longer periods and in more convenient form than any now otherwise easily accessible, and to urge others by example at least to put other data in the same convenient form.

The Croton River flow records have been kept continuously since 1868, and the size of the drainage area, its proximity to Connecticut, and the length of time covered by the observations, make these the most valuable monthly records we have for water power purposes.

Table 1 gives these records reduced to second-feet per square mile arranged chronologically. For the purpose of determining the value of storage, or for calculating the yield of the stream for water works purposes, this is the proper order.

Table 2 gives the same records with the monthly flow of each year arranged in order of magnitude. For the purpose of obtaining the average available power of a stream at different developments for a long term of years, for determining the average and maximum amount of auxiliary power needed at any development, and the damages incident to the diversion of the whole, or a part of the water of any stream, table 2 gives results more nearly correct than Table 1.

Table 3 gives the same records with the monthly flows of the whole term arranged in order of magnitude. This form gives results still nearer correct than the form in table 2.

Table 4 compares the results of the three methods of averaging.

Table 5 treats the data in a perfectly logical way, averaging and massing the *duration* of each rate of flow.

This is the only form of averaging the whole that gives the flow of the minimum month, the maximum month, and the true available flow at different developments. It gives the *duration of every flow*, which is just what is needed.

Column A gives all the rates of flow of the whole term in order of magnitude, regardless of the years in which they occur.

Column B gives the number of months in which each rate occurred.

Column C masses the months and hence gives the number of months in which the flow did not exceed that in column A.

D is the product of A and B.

E the massed products.

Multiplying C, the massed months, by O, gives the average massed days for each year in column F.

G gives the average flow of the massed months.

H gives the average available flow at any development (A) for the whole average year.

Tables 6, 7, and 8 give the Sudbury River records from 1875 to 1906 inclusive in the chronological order, order of magnitude by years, and order of magnitude of the whole term.

The long term of thirty-two years is in their favor, but the comparatively small drainage area makes them less valuable for water power uses, though they have been used for water power purposes very largely.

Tables 9, 10, and 11 give the Nashua River records from 1897 to 1906 in the same three ways. Table 12 compares the results. These observations, covering only ten years on a drainage area of but 119 square miles, naturally have less value than longer records on larger watersheds, but their comparative proximity to Connecticut and their accuracy make them well worthy of consideration.

The records of flow that form the basis of all the tables regarding the Croton, Sudbury, and Nashua Rivers are from calculations made monthly; that is, they are the average flows of their respective months. On this account they indicate a more uniform flow than really exists. On the other hand the drainage areas of the Croton and Sudbury Rivers contained large water surfaces in comparison with streams used for power in Connecticut, which causes the run-off to be less than it otherwise would.

Offsetting these things against one another, it is probable that the tables, averaged in order of magnitude for the whole term, fairly represent the capacities of the streams whose flows are recorded.

In spite of the long continued observations at Croton and Sudbury, and the fact that their records have served a useful purpose for a long time in water power matters, it is probable that we ought in the future to pay more attention to the larger streams actually used for power purposes.

Daily records, grouped by weeks to avoid the effect of Sunday and holiday closing, are much more useful than monthly calculations.

Table 13 gives the weekly flows of the Merrimac River at Lawrence for seventeen years arranged in order of magnitude for the whole term. The value of this record for water power purpose exceeds, in the opinion of the writer, that of monthly calculations. It shows just what flows are obtained in actual practice with the effect of storage and pondage included. Much

of this flow is measured for the actual sale of the water, and the accuracy probably exceeds that of the usual measurements of undeveloped streams.

Table 14 gives from the Merrimac records, for each tenth of a second-foot per square mile of drainage area, the average flow available, the number of weeks when there was a lack of water, the number of weeks when there was sufficient water, and the percentage of any development that can be realized.

Probably no records of the flows of New England streams exceed in value for water power purposes in Connecticut those made at Holyoke, Mass., during the nineteen years from 1881 to 1899 inclusive.

On account of the form of the new dam, and the effect of the remains of the old dam, the records of total flow of the Connecticut River there have not been maintained since the latter date. Hence this is a complete chapter, and all its lessons should be made available for the use of engineers.

The records in the form of cubic feet per second for the whole drainage area, by differences of fifty, arranged in order of magnitude for each year, were kindly furnished by Mr. Sickman to the writer in 1900 for special use, and the writer made a table like Table 15, putting in the first column the flows above mentioned, and in the second column the flows reduced to second-feet per square mile.

In double columns, headed by the different years, were put the number of days each flow occurred, and the massed number, thus showing at what number of days from the driest days each flow occurred.

Another double column shows the sum of all previous columns of days, which, divided by nineteen, the number of years, gives in still another double column the average number of times each flow and any massed flow occurred during the whole term.

In this way no flow was averaged with a greater or smaller flow. *Days were averaged, not flows.*

The flows are week-day flows only. Sunday flows are not included. This makes the table very practical and well adapted to working conditions. At times of low water the balance of the week gets the benefit of the Sunday flow; when water is running to waste the flow of balance of week is not affected.

Influence of reservoirs and mill ponds is included in the records. That is, the records show just what was obtained at

Holyoke under the practical conditions stated, and they are the best evidence obtainable of what can be expected in the future as an average of a long term, and how bad the bad years are liable to be, and how good the good years. They are also very valuable as indicating what may be expected on other streams when due allowance is made for difference in conditions.

Table 16 gives by tenths of second-feet per square mile for twenty-four hours the equivalent in ten hours, and the equivalents of both in horse power per foot-mile. It gives the average number of days the different flows occurred at Holyoke, and the average number of days during which auxiliary power would be needed at each development.

It also gives the average flow and power on the short days, and the average flow and power available throughout the year at any development. A column is added giving the average available in form of percentage of the development.

Table 17 compares the records of Croton, Sudbury, and the Connecticut at Holyoke for the same twenty years. It gives the average number of days each flow by tenths of second-feet per square mile occurred, the average number of days auxiliary power was needed at any development, and the relation the available flow bears to the development.

So far as the writer knows, nearly all long term averages that can be found in print are from monthly calculations averaged chronologically. They indicate as available at different developments a much larger flow than the records warrant.

The Holyoke data for nineteen years should be in print, available for the use of engineers, in three forms:

1. A table showing the flow in second-feet per square mile of each day of each year chronologically.
2. A table giving all the week-day flows arranged in order of magnitude for each year.
3. A table giving all the week-day flows arranged in order of magnitude for the whole term.

If this paper and one read by the writer before the New England Water Works Association, November 13, 1907, should lead to the publishing of stream flow data in a more convenient form than that in general use, or in getting the Holyoke data in print in the above forms, the results will justify the considerable labor necessary in preparing these tables.

TABLE I.

CROTON RIVER. DRAINAGE AREA, 338.8 SQUARE MILES.

Monthly data. Flow in cubic feet per second per square mile arranged chronolog

	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1868	1.52	.68	3.39	3.04	4.64	2.64	.85	1.59	.44	2.29	2.75	1.21	25.04
1869	1.74	1.60	4.32	2.71	2.21	1.05	.46	.26	.16	2.07	1.66	2.49	20.82
1870	3.07	3.70	2.74	3.59	1.38	.64	.39	.39	.28	.33	.49	.46	17.46
1871	.45	1.90	2.71	1.57	1.56	1.12	.53	.65	.48	1.54	2.98	1.74	17.23
1872	1.58	.99	1.33	2.47	.96	.94	.46	1.26	.95	.83	2.12	1.08	14.97
1873	3.33	1.42	3.14	5.79	1.65	.42	.37	.55	.41	1.09	1.34	2.32	21.83
1874	8.19	2.37	2.31	2.89	2.45	.70	1.08	.67	.45	.59	.54	.70	22.94
1875	.46	3.55	2.49	4.51	1.39	.44	.43	4.22	.67	.63	1.74	1.36	21.89
1876	1.10	3.07	5.52	5.03	1.53	.53	.41	.38	.30	.29	.55	.36	19.07
1877	.61	1.25	5.37	2.34	.67	.47	.38	.37	.27	.79	3.45	1.49	17.46
1878	2.24	3.31	3.00	1.31	1.17	1.15	.55	.49	1.87	.69	1.64	6.06	23.48
1879	1.07	2.36	3.31	4.08	1.45	.69	.55	1.08	.87	.48	.62	1.46	18.02
1880	2.09	2.41	2.26	1.63	.67	.41	.41	.38	.39	.38	.44	.41	11.88
1881	.56	3.91	4.69	1.47	1.04	1.34	.43	.41	.41	.41	.36	1.36	16.39
1882	1.81	3.79	4.03	1.11	1.78	1.33	.52	.41	2.65	1.72	.74	.98	20.87
1883	.86	2.98	2.25	2.17	1.03	.53	.41	.41	.39	.50	.53	.47	12.53
1884	1.54	4.77	3.96	2.40	1.46	.52	.63	.92	.57	.42	.78	3.04	21.01
1885	3.38	2.18	1.57	2.09	1.21	.46	.39	.44	.35	.42	1.67	1.62	15.78
1886	2.75	4.22	1.94	3.81	1.65	.63	.46	.43	.39	.39	.69	.93	18.29
1887	2.24	4.42	2.94	2.69	1.01	.94	2.09	2.81	.72	.81	.77	1.92	23.36
1888	3.24	4.06	3.79	4.13	2.12	1.11	.43	.85	2.67	2.00	2.54	4.25	31.19
1889	3.55	2.04	1.62	2.08	1.34	1.45	1.23	3.29	1.85	1.49	4.41	3.70	28.05
1890	1.78	2.82	3.86	2.68	2.09	1.35	.66	.48	1.71	2.68	1.69	1.33	23.13
1891	5.62	5.19	3.45	2.01	.74	.64	.65	.67	.66	.64	.56	.98	21.81
1892	2.97	1.23	1.49	.97	1.15	.98	.73	.71	.78	.68	1.24	1.30	14.23
1893	1.49	2.55	5.09	2.83	4.79	.84	.74	.86	.75	.98	1.25	2.60	24.77
1894	1.31	1.83	4.03	1.93	1.47	1.25	.76	.74	.77	.72	1.95	1.77	18.53
1895	2.35	.91	2.68	3.15	1.04	.75	.75	.78	.82	.75	.72	.75	15.45
1896	1.03	2.07	4.62	2.34	.47	.92	.85	.92	.88	.89	1.29	.91	17.19
1897	1.10	1.90	2.44	2.01	2.26	1.19	2.13	2.44	1.01	.88	.91	1.79	20.06
1898	2.98	4.34	2.62	1.76	3.89	1.55	.95	1.77	1.03	1.15	1.67	2.67	26.38
1899	3.17	2.57	6.06	3.30	.99	1.03	1.01	1.05	1.02	1.04	1.04	1.03	23.31
1900	1.53	6.26	4.77	1.73	2.19	.63	.39	.10	.27	.48	1.18	1.67	21.20
1901	1.06	.46	4.47	6.78	3.70	1.44	1.23	3.75	1.93	2.32	1.11	4.08	32.33
1902	3.28	2.82	8.55	2.88	1.56	.74	.64	.50	.62	2.10	1.27	4.79	29.75
1903	3.15	3.50	5.24	3.02	.54	2.95	1.36	1.32	1.62	4.35	1.53	2.36	31.00
1904	2.00	2.62	4.73	2.85	1.42	1.04	.74	1.06	2.28	1.38	1.23	.95	22.30
1905	3.80	1.13	3.76	3.11	.80	1.04	.33	.45	1.17	.64	.54	1.03	17.80
Total	86.00	103.33	136.54	106.26	63.47	37.85	27.38	39.86	34.86	41.84	51.99	69.42	798.80
Aver.	2.26	2.72	3.59	2.80	1.67	1.00	.72	1.05	.92	1.10	1.37	1.83	21.02

TABLE II.

CROTON RIVER. DRAINAGE AREA, 338.8 SQUARE MILES.

thly data. Flow in cubic feet per second per square mile arranged in order of magnitude in each year.

1	2	3	4	5	6	7	8	9	10	11	12	Total.	Aver.
.44	.68	.85	1.21	1.52	1.59	2.29	2.64	2.75	3.04	3.39	4.64	25.04	2.45
.16	.26	.46	1.05	1.66	1.69	1.74	2.07	2.21	2.49	2.71	4.32	20.82	1.74
.28	.33	.39	.39	.46	.49	.64	1.38	2.74	3.07	3.59	3.70	17.46	1.44
.45	.48	.53	.65	1.12	1.54	1.56	1.57	1.74	1.90	2.71	2.98	17.23	1.43
.46	.83	.94	.95	.96	.99	1.08	1.26	1.33	1.58	2.12	2.47	14.97	1.24
.37	.41	.42	.55	1.09	1.34	1.42	1.65	2.32	3.14	3.33	5.79	21.83	1.84
.45	.54	.59	.67	.70	.70	1.08	2.31	2.37	2.45	2.89	8.19	22.94	1.83
.43	.44	.46	.63	.67	1.36	1.39	1.74	2.49	3.55	4.22	4.51	21.89	1.81
.29	.30	.36	.38	.41	.53	.55	1.10	1.53	3.07	5.03	5.52	19.07	1.58
.27	.37	.38	.47	.61	.67	.79	1.25	1.49	2.34	3.45	5.37	17.46	1.46
.49	.55	.69	1.15	1.17	1.31	1.64	1.87	2.24	3.00	3.31	6.06	23.48	1.95
.48	.55	.62	.69	.87	1.07	1.08	1.45	1.46	2.36	3.31	4.08	18.02	1.49
.38	.38	.39	.41	.41	.41	.44	.67	1.63	2.09	2.26	2.41	11.88	.98
.36	.41	.41	.41	.43	.56	1.04	1.34	1.36	1.47	3.91	4.69	16.39	1.35
.41	.52	.74	.98	1.11	1.33	1.72	1.78	1.81	2.65	3.79	4.03	20.87	1.73
.39	.41	.41	.47	.50	.53	.53	.86	1.03	2.17	2.25	2.98	12.53	1.03
.42	.52	.57	.63	.78	.92	1.46	1.54	2.40	3.04	3.96	4.77	21.01	1.72
.35	.39	.42	.44	.46	1.21	1.57	1.62	1.67	2.09	2.18	3.38	15.78	1.31
.39	.39	.43	.46	.63	.69	.93	1.65	1.94	2.75	3.81	4.22	18.29	1.50
.72	.77	.81	.94	1.01	1.92	2.09	2.24	2.69	2.81	2.94	4.42	23.36	1.83
.43	.85	1.11	2.00	2.12	2.54	2.67	3.24	3.79	4.06	4.13	4.25	31.19	2.59
1.23	1.34	1.45	1.49	1.62	1.85	2.04	2.08	3.29	3.55	3.70	4.41	28.05	2.32
.48	.66	1.33	1.35	1.69	1.71	1.78	2.09	2.68	2.68	2.82	3.86	23.13	1.91
.56	.64	.64	.65	.66	.67	.74	.98	2.01	3.45	5.19	5.62	21.81	1.80
.68	.71	.73	.78	.97	.98	1.15	1.23	1.24	1.30	1.49	2.97	14.23	1.19
.74	.75	.84	.86	.98	1.25	1.49	2.55	2.60	2.83	4.79	5.09	24.77	2.06
.72	.74	.76	.77	1.25	1.31	1.47	1.77	1.83	1.93	1.95	4.03	18.53	1.54
.72	.75	.75	.75	.75	.78	.82	.91	1.04	2.35	2.68	3.15	15.45	1.29
.47	.85	.88	.89	.91	.92	.92	1.03	1.29	2.07	2.34	4.62	17.19	1.47
.88	.91	1.01	1.10	1.19	1.79	1.90	2.01	2.13	2.26	2.44	2.44	20.06	1.68
.95	1.03	1.15	1.55	1.67	1.76	1.77	2.62	2.67	2.98	3.89	4.34	26.38	2.19
.99	1.01	1.02	1.03	1.03	1.04	1.04	1.05	2.57	3.17	3.30	6.06	23.31	1.94
.10	.27	.39	.48	0.63	1.18	1.53	1.67	1.73	2.19	4.77	6.26	21.20	1.74
.46	1.06	1.11	1.23	1.44	1.93	2.32	3.70	3.75	4.08	4.47	6.78	32.33	2.71
.50	.62	.64	.74	1.27	1.56	2.10	2.82	2.88	3.28	4.79	8.55	29.75	2.49
.54	1.32	1.36	1.53	1.62	2.36	2.95	3.02	3.15	3.56	4.35	5.24	31.00	2.58
.74	.95	1.04	1.06	1.23	1.38	1.42	2.00	2.28	2.62	2.85	4.73	22.30	1.86
.33	.45	.54	.64	.80	1.03	1.04	1.13	1.17	3.11	3.76	3.80	17.80	1.50
19.51	24.44	27.62	32.43	38.40	46.89	54.19	67.89	81.30	102.53	128.87	174.73	798.80	1.75
.51	.64	.73	.85	1.01	1.23	1.43	1.79	2.14	2.70	3.39	4.60	21.02	

TABLE III.

CROTON RIVER. 1868 TO 1905 INCLUSIVE.
DRAINAGE AREA, 338.8 SQUARE MILES. MONTHLY DATA.

Flow in cubic feet per second per square mile arranged in order of magnitude
for whole term instead of each year separately.

1	2	3	4	5	6	7	8	9	10	11	12
.10	.42	.54	.70	.91	1.06	1.33	1.59	2.00	2.44	3.02	4.03
.16	.42	.54	.71	.91	1.06	1.33	1.62	2.01	2.45	3.04	4.03
.26	.42	.54	.72	.91	1.07	1.33	1.62	2.01	2.47	3.04	4.06
.27	.43	.55	.72	.92	1.08	1.34	1.62	2.04	2.49	3.07	4.08
.27	.43	.55	.72	.92	1.08	1.34	1.63	2.07	2.49	3.07	4.08
.28	.43	.55	.73	.92	1.08	1.34	1.64	2.07	2.54	3.11	4.13
.29	.43	.55	.74	.93	1.09	1.35	1.65	2.08	2.55	3.14	4.22
.30	.44	.56	.74	.94	1.10	1.36	1.65	2.09	2.57	3.15	4.22
.23	.44	.56	.74	.94	1.10	1.36	1.66	2.09	2.60	3.15	4.25
.33	.44	.57	.74	.95	1.11	1.36	1.67	2.09	2.62	3.17	4.32
.35	.44	.59	.74	.95	1.11	1.38	1.67	2.09	2.62	3.24	4.34
.36	.45	.61	.74	.95	1.11	1.38	1.67	2.10	2.64	3.28	4.35
.36	.45	.62	.75	.96	1.12	1.39	1.69	2.12	2.65	3.29	4.41
.37	.45	.62	.75	.97	1.13	1.42	1.69	2.12	2.67	3.30	4.42
.37	.46	.63	.75	.98	1.15	1.42	1.71	2.13	2.67	3.31	4.47
.38	.46	.63	.75	.98	1.15	1.44	1.72	2.17	2.68	3.31	4.51
.38	.46	.63	.75	.98	1.15	1.45	1.73	2.18	2.68	3.33	4.62
.38	.46	.63	.76	.98	1.17	1.45	1.74	2.19	2.68	3.38	4.64
.38	.46	.64	.77	.99	1.17	1.46	1.74	2.21	2.69	3.39	4.69
.39	.46	.64	.77	.99	1.18	1.46	1.74	2.24	2.71	3.45	4.73
.39	.46	.64	.78	1.01	1.19	1.47	1.76	2.24	2.71	3.45	4.77
.39	.47	.64	.78	1.01	1.21	1.47	1.77	2.25	2.74	3.55	4.77
.39	.47	.64	.78	1.01	1.21	1.49	1.77	2.26	2.75	3.55	4.79
.39	.47	.65	.79	1.02	1.23	1.49	1.78	2.26	2.75	3.56	4.79
.39	.48	.65	.80	1.03	1.23	1.49	1.78	2.28	2.81	3.59	5.03
.39	.48	.66	.81	1.03	1.23	1.49	1.79	2.29	2.82	3.70	5.09
.39	.48	.66	.82	1.03	1.23	1.52	1.81	2.31	2.82	3.70	5.19
.41	.48	.67	.83	1.03	1.24	1.53	1.83	2.32	2.83	3.70	5.24
.41	.49	.67	.84	1.03	1.25	1.53	1.85	2.32	2.85	3.75	5.37
.41	.49	.67	.85	1.03	1.25	1.53	1.87	2.34	2.88	3.76	5.52
.41	.50	.67	.85	1.04	1.25	1.54	1.90	2.34	2.89	3.79	5.62
.41	.50	.67	.85	1.04	1.26	1.54	1.90	2.35	2.94	3.79	5.79
.41	.52	.68	.86	1.04	1.27	1.55	1.92	2.36	2.95	3.80	6.06
.41	.52	.68	.86	1.04	1.29	1.56	1.93	2.36	2.97	3.81	6.06
.41	.53	.69	.87	1.04	1.30	1.56	1.93	2.37	2.98	3.86	6.26
.41	.53	.69	.88	1.04	1.31	1.57	1.94	2.40	2.98	3.89	6.78
.41	.53	.69	.88	1.05	1.31	1.57	1.95	2.41	2.98	3.91	8.19
.41	.53	.70	.89	1.05	1.32	1.58	2.00	2.44	3.00	3.96	8.55
13.55	17.78	23.77	29.81	37.55	44.85	55.17	66.93	84.00	103.56	131.36	190.47
0.36	0.48	0.63	0.78	0.99	1.18	1.45	1.76	2.21	2.73	3.46	5.01

TABLE IV.

CROTON RIVER. DRAINAGE AREA, 338.8 SQUARE MILES.
MONTHLY DATA. 1868 TO 1905 INCLUSIVE.

Comparison of Available Flow Averaged by Three Different Methods.

- A. Average flow in second feet per square mile.
B. Massed flow.
C. Average flow of months equal to or less than development "A."
D. Average available flow for the year with development "A."

MONTHS.	Chronologically.				Order of Magnitude by Years.				Order of Magnitude of Whole Term.			
	A	B	C	D	A	B	C	D	A	B	C	D
1 July....	.72	.72	.72	.72	.51	.51	.51	.51	.36	.36	.36	.36
2 Sept....	.92	1.64	.82	.90	.64	1.15	.58	.63	.46	.82	.41	.45
3 June....	1.00	2.64	.88	.97	.73	1.88	.63	.70	.62	1.44	.48	.59
4 Aug....	1.05	3.69	.92	1.01	.85	2.73	.68	.79	.78	2.22	.55	.71
5 Oct....	1.10	4.79	.96	1.04	1.01	3.74	.75	.90	.99	3.21	.64	.85
6 Nov....	1.37	6.16	1.03	1.20	1.23	4.97	.83	1.03	1.15	4.39	.73	.96
7 May....	1.67	7.83	1.12	1.35	1.43	6.40	.91	1.13	1.45	5.84	.83	1.09
8 Dec....	1.83	9.66	1.21	1.42	1.79	8.19	1.02	1.28	1.76	7.60	.95	1.22
9 Jan....	2.26	11.92	1.32	1.56	2.14	10.33	1.15	1.39	2.21	9.81	1.09	1.37
10 Feb....	2.72	14.63	1.46	1.67	2.70	13.03	1.30	1.54	2.73	12.54	1.25	1.50
11 April....	2.80	17.43	1.58	1.69	3.39	16.42	1.49	1.65	3.46	16.00	1.45	1.62
12 March..	3.59	21.02	1.75	1.75	4.60	21.02	1.75	1.75	5.01	21.01	1.75	1.75

TABLE V.

CROTON RIVER, NEW YORK.

THIRTY-EIGHT YEARS, 1869 TO 1905 INCLUSIVE. DRAINAGE AREA, 335.5
SQUARE MILES.

Original Data Calculated Monthly.

- A. Flow in cubic feet per second per square mile.
 B. Number of months this flow occurred in the whole term of years.
 C. Number of months this flow and all lower flows combined occurred.
 D. Product of each flow by the number of months it occurred ($A \times B$).
 E. Sum of products for this flow and all lower flows.
 F. Average number of days per year this flow occurred in whole term of years ($C \times .8 = F$).
 G. Average flow of all days below and including this flow.
 H. Average flow for the whole year with development equal to this flow,

$$\frac{(365 - F) A + (F \times G)}{365}$$

A	B	C	D	E	F	G	H
.10	1	1	.10	.10	1	.10	.10
.16	1	2	.16	.26	2	.13	.16
.26	1	3	.26	.52	3	.17	.26
.27	2	5	.54	1.06	4	.21	.27
.28	1	6	.28	1.34	5	.22	.28
.29	1	7	.29	1.63	6	.23	.29
.30	1	8	.30	1.93	7	.24	.30
.33	2	10	.66	2.59	8	.26	.33
.35	1	11	.35	2.94	9	.27	.35
.36	2	13	.72	3.66	10	.28	.36
.37	2	15	.74	4.40	12	.29	.37
.38	4	19	1.52	5.92	15	.31	.38
.39	8	27	3.12	9.04	22	.33	.39
.41	11	38	4.51	13.55	30	.35	.40
.42	3	41	1.26	14.81	33	.36	.41
.43	4	45	1.72	16.53	36	.37	.42
.44	4	49	1.76	18.29	39	.37	.43
.45	3	52	1.35	19.64	41	.38	.44
.46	7	59	3.22	22.86	47	.39	.45
.47	3	62	1.41	24.27	49	.39	.46
.48	4	66	1.92	26.19	53	.40	.47
.49	2	68	.98	27.17	54	.40	.48
.50	2	70	1.00	28.17	56	.40	.49
.52	2	72	1.04	29.21	57	.41	.50
.53	4	76	2.12	31.33	60	.41	.51
.54	3	79	1.62	32.95	63	.42	.52
.55	4	83	2.20	35.15	66	.42	.53
.56	2	85	1.12	36.27	68	.43	.54
.57	1	86	.57	36.84	69	.43	.55
.59	1	87	.59	37.43	70	.43	.56
.61	1	88	.61	38.04	71	.43	.57
.62	2	90	1.24	39.28	72	.44	.58
.63	4	94	2.52	41.80	75	.44	.59
.64	5	99	3.20	45.00	79	.45	.60
.65	2	101	1.30	46.30	81	.46	.61

TABLE V—Continued.

A	B	C	D	E	F	G	H
.66	2	103	1.32	47.62	82	.46	.61
.67	5	108	3.35	50.97	86	.47	.62
.68	2	110	1.36	52.33	88	.48	.63
.69	3	113	2.07	54.40	90	.48	.64
.70	2	115	1.40	55.80	92	.49	.64
.71	1	116	.71	56.51	93	.49	.65
.72	3	119	2.16	58.67	95	.49	.65
.73	1	120	.73	59.40	96	.50	.66
.74	6	126	4.44	63.84	100	.51	.68
.75	5	131	3.75	67.89	105	.52	.68
.76	1	132	.76	68.35	106	.52	.69
.77	2	134	1.54	69.89	107	.52	.70
.78	3	137	2.34	72.23	110	.53	.70
.79	1	138	.79	73.02	110	.53	.72
.80	1	139	.80	73.82	111	.53	.72
.81	1	140	.81	74.63	112	.53	.72
.82	1	141	.82	75.45	113	.54	.73
.83	1	142	.83	76.38	114	.54	.74
.84	1	143	.84	77.12	115	.54	.75
.85	3	146	2.55	79.67	117	.55	.75
.86	2	148	1.72	81.39	118	.55	.76
.87	1	149	.87	82.26	119	.55	.76
.88	2	151	1.76	84.02	121	.56	.77
.89	1	152	.89	84.91	122	.56	.78
.91	3	155	2.73	87.64	124	.57	.79
.92	3	158	2.76	90.40	126	.57	.80
.93	1	159	.93	91.33	127	.57	.80
.94	2	161	1.88	93.21	129	.58	.82
.95	3	164	2.85	96.06	131	.59	.82
.96	1	165	.96	97.02	132	.59	.83
.97	1	166	.97	97.99	133	.60	.83
.98	4	170	3.92	101.91	136	.60	.84
.99	2	172	1.98	103.89	138	.60	.84
1.01	3	175	3.03	106.92	140	.60	.85
1.02	7	176	1.02	107.94	141	.60	.86
1.03	6	182	6.18	114.12	145	.63	.87
1.04	6	188	6.24	120.36	150	.64	.88
1.05	2	190	2.10	122.46	152	.64	.88
1.06	2	192	2.12	124.58	154	.65	.89
1.07	1	193	1.07	125.65	154	.65	.89
1.08	3	196	3.24	129.89	157	.66	.90
1.09	1	197	1.09	129.98	158	.66	.90
1.10	2	199	2.20	132.18	159	.66	.91
1.11	3	202	3.33	135.51	162	.67	.91
1.12	1	203	1.12	136.63	162	.67	.92
1.13	1	204	1.13	137.76	163	.68	.93
1.15	3	207	3.45	141.21	166	.68	.94
1.17	2	209	2.34	143.55	167	.69	.95
1.18	1	210	1.18	144.73	168	.69	.95
1.19	1	211	1.19	145.92	169	.69	.96
1.21	2	213	2.42	148.34	170	.70	.97
1.23	4	217	4.92	153.26	174	.70	.98
1.24	1	218	1.24	154.50	173	.70	.98
1.25	3	221	3.75	158.25	177	.72	.99
1.26	1	222	1.26	159.51	177	.72	1.00

TABLE V—Continued.

A	B	C	D	E	F	G	H
1.27	1	223	1.27	160.78	178	.72	1.00
1.29	1	224	1.29	162.07	179	.72	1.01
1.30	1	225	1.30	163.37	180	.73	1.02
1.31	2	227	2.62	165.99	181	.73	1.02
1.32	1	228	1.32	167.31	182	.73	1.03
1.33	3	231	3.99	177.30	185	.74	1.03
1.34	3	234	4.12	175.32	187	.75	1.04
1.35	1	235	1.35	176.67	188	.75	1.04
1.36	3	238	4.08	180.75	190	.76	1.05
1.38	2	240	2.76	183.51	192	.76	1.05
1.39	1	241	1.39	184.90	193	.77	1.06
1.42	2	243	2.84	187.74	194	.78	1.06
1.44	1	244	1.44	189.18	195	.78	1.07
1.45	2	245	2.90	192.08	197	.78	1.09
1.46	2	248	2.92	195.00	198	.79	1.10
1.47	2	250	2.94	197.94	200	.79	1.10
1.49	4	254	5.96	203.90	203	.80	1.11
1.52	1	255	1.52	205.42	204	.81	1.12
1.53	3	258	4.59	210.01	206	.81	1.12
1.54	2	260	3.08	213.09	208	.82	1.13
1.55	1	261	1.55	215.64	209	.82	1.13
1.56	2	263	3.12	218.76	210	.83	1.14
1.57	2	265	3.14	221.90	212	.84	1.14
1.58	1	266	1.58	222.48	213	.84	1.15
1.59	1	267	1.59	224.07	214	.84	1.15
1.62	3	270	4.86	228.93	216	.85	1.16
1.63	1	271	1.63	230.56	217	.85	1.17
1.64	1	272	1.64	232.20	217	.85	1.17
1.65	2	274	3.30	235.50	219	.86	1.18
1.66	1	275	1.66	237.16	220	.86	1.18
1.67	3	278	5.01	242.17	222	.87	1.18
1.69	2	280	3.28	245.45	224	.88	1.19
1.71	1	281	1.71	247.16	225	.88	1.20
1.72	1	282	1.72	248.88	225	.88	1.20
1.73	1	283	1.73	250.61	226	.89	1.21
1.74	3	286	5.22	255.83	228	.89	1.21
1.76	1	287	1.76	257.59	230	.90	1.22
1.77	2	289	3.54	261.13	231	.90	1.22
1.78	2	291	3.56	264.69	233	.91	1.23
1.79	1	292	1.79	266.48	233	.91	1.23
1.81	1	293	1.81	268.29	234	.92	1.23
1.83	1	294	1.83	270.12	235	.92	1.24
1.85	11	295	1.85	270.97	236	.92	1.25
1.87	1	296	1.87	272.84	237	.92	1.25
1.90	2	298	3.80	276.64	238	.93	1.27
1.92	1	299	1.92	278.56	239	.93	1.27
1.93	2	301	3.86	282.42	241	.94	1.28
1.94	1	302	1.94	284.36	242	.94	1.28
1.95	1	303	1.95	286.31	242	.94	1.28
2.00	2	305	4.00	290.31	244	.95	1.30
2.01	2	307	4.02	294.33	246	.96	1.30
2.04	1	308	2.04	296.37	246	.96	1.31
2.07	2	310	4.14	300.51	248	.97	1.32
2.08	1	311	2.08	302.59	249	.97	1.32
2.09	4	315	8.36	311.95	252	.99	1.33

TABLE V—Continued.

A	B	C	D	E	F	G	H
2.10	1	316	2.10	314.05	253	.99	1.33
2.12	2	318	4.24	318.29	254	1.00	1.34
2.13	1	319	2.13	320.42	255	1.00	1.34
2.17	1	320	2.17	322.59	256	1.01	1.35
2.18	1	321	2.18	324.77	257	1.01	1.36
2.19	1	322	2.19	326.96	258	1.01	1.36
2.21	1	323	2.21	329.17	258	1.02	1.37
2.24	2	325	4.48	333.65	260	1.03	1.37
2.25	1	326	2.25	335.90	261	1.03	1.37
2.26	2	328	4.52	340.42	262	1.04	1.38
2.28	1	329	2.28	342.70	263	1.04	1.39
2.29	1	330	2.29	344.99	264	1.05	1.39
2.31	1	331	2.31	347.30	265	1.05	1.39
2.32	2	333	4.64	351.94	266	1.06	1.40
2.34	2	335	4.68	356.62	268	1.06	1.40
2.35	1	336	2.35	358.97	269	1.07	1.40
2.36	2	338	4.72	363.69	270	1.08	1.41
2.37	1	339	2.37	366.06	271	1.08	1.41
2.40	1	340	2.40	368.46	272	1.08	1.42
2.41	1	341	2.41	370.87	273	1.09	1.42
2.44	2	343	4.88	375.75	274	1.09	1.43
2.45	1	344	2.45	378.20	275	1.10	1.43
2.47	1	345	2.47	380.67	276	1.10	1.44
2.49	2	347	4.98	385.65	278	1.11	1.44
2.54	1	348	2.54	388.19	278	1.12	1.45
2.55	1	349	2.55	390.74	279	1.12	1.46
2.57	1	350	2.57	393.31	280	1.12	1.46
2.60	1	351	2.60	395.91	281	1.12	1.46
2.62	2	353	5.24	401.15	282	1.13	1.47
2.64	1	354	2.64	403.79	283	1.14	1.48
2.65	1	355	2.65	406.44	284	1.14	1.48
2.67	2	357	5.34	411.78	286	1.15	1.48
2.68	3	360	8.04	419.82	288	1.16	1.48
2.69	1	361	2.69	422.51	289	1.17	1.49
2.71	2	363	5.42	427.93	290	1.17	1.49
2.74	1	364	2.74	430.67	291	1.18	1.50
2.75	2	366	5.50	436.17	293	1.19	1.50
2.81	1	367	2.81	438.98	294	1.19	1.51
2.82	2	369	5.64	444.62	295	1.20	1.51
2.83	1	370	2.83	447.45	296	1.20	1.51
2.85	1	371	2.85	450.30	297	1.21	1.52
2.88	1	372	2.88	453.18	298	1.21	1.52
2.89	1	373	2.89	456.07	298	1.21	1.52
2.94	1	374	2.94	459.01	299	1.21	1.52
2.95	1	375	2.95	461.96	300	1.23	1.54
2.97	1	376	2.97	464.93	301	1.23	1.54
2.98	3	379	8.94	473.87	303	1.23	1.54
3.00	1	380	3.00	476.87	304	1.25	1.54
3.02	1	381	3.02	479.89	305	1.26	1.55
3.04	2	383	6.08	485.97	306	1.27	1.56
3.07	2	385	6.14	492.11	308	1.27	1.56
3.11	1	386	3.11	495.22	309	1.28	1.56
3.14	1	387	3.14	498.36	310	1.28	1.56
3.15	2	389	6.30	504.66	311	1.29	1.57

TABLE V—*Concluded.*

A	B	C	D	E	F	G	H
3.17	1	390	3.17	507.83	312	1.29	1.52
3.24	1	391	3.24	511.07	313	1.30	1.52
3.28	1	392	3.28	514.35	314	1.31	1.59
3.29	1	393	3.29	517.64	314	1.31	1.59
3.30	1	394	3.30	520.94	315	1.32	1.59
3.31	2	396	6.62	527.56	317	1.33	1.59
3.33	1	397	3.33	530.89	318	1.33	1.59
3.33	1	398	3.38	534.27	318	1.34	1.60
3.39	1	399	3.39	537.66	319	1.34	1.60
3.45	2	401	6.90	544.56	321	1.36	1.61
3.55	2	403	7.10	551.66	322	1.37	1.63
3.56	1	404	3.56	555.22	323	1.37	1.63
3.59	1	405	3.59	558.81	324	1.38	1.63
3.70	3	408	11.10	569.91	326	1.39	1.64
3.75	1	409	3.75	573.66	327	1.40	1.65
3.76	1	410	3.76	577.42	328	1.41	1.65
3.79	2	412	7.58	585.06	330	1.42	1.65
3.80	1	413	3.80	588.80	330	1.42	1.65
3.81	1	414	3.81	592.61	331	1.43	1.65
3.86	1	415	3.86	596.47	332	1.43	1.65
3.89	1	416	3.89	600.36	333	1.44	1.66
3.91	1	417	3.91	604.27	334	1.45	1.66
3.96	1	418	3.96	608.23	334	1.45	1.66
4.03	2	420	8.06	616.29	336	1.47	1.67
4.06	1	421	4.06	620.35	337	1.47	1.67
4.08	2	423	8.16	628.51	338	1.48	1.67
4.13	1	424	4.13	632.64	339	1.49	1.68
4.22	2	426	8.44	641.08	341	1.50	1.68
4.25	1	427	4.25	645.33	342	1.51	1.68
4.32	1	428	4.32	649.65	342	1.52	1.69
4.34	1	429	4.34	653.99	343	1.52	1.69
4.35	1	430	4.35	658.34	344	1.53	1.69
4.41	1	431	4.41	662.75	345	1.54	1.70
4.42	1	432	4.42	667.17	346	1.54	1.70
4.47	1	433	4.47	671.64	346	1.55	1.70
4.51	1	434	4.51	676.15	347	1.56	1.71
4.62	1	435	4.62	680.77	348	1.56	1.71
4.64	1	436	4.64	685.41	349	1.57	1.71
4.69	1	437	4.69	690.10	350	1.58	1.71
4.73	1	438	4.73	694.83	350	1.58	1.71
4.77	2	440	9.54	704.37	352	1.59	1.71
4.79	2	442	9.58	713.95	354	1.61	1.71
5.03	1	443	5.03	718.98	354	1.61	1.71
5.09	1	444	5.09	724.07	355	1.62	1.71
5.19	1	445	5.19	729.26	356	1.63	1.71
5.24	1	446	5.24	734.50	357	1.64	1.72
5.37	1	447	5.37	739.87	358	1.65	1.72
5.52	1	448	5.52	745.39	358	1.66	1.73
5.62	1	449	5.62	751.01	359	1.67	1.74
5.79	1	450	5.79	756.80	360	1.68	1.74
6.06	2	452	12.12	768.92	362	1.70	1.74
6.26	1	453	6.26	775.18	362	1.71	1.75
6.78	1	454	6.78	781.96	363	1.72	1.75
8.19	1	455	8.19	790.15	364	1.73	1.75
8.55	1	456	8.55	798.70	365	1.75	1.75

TABLE VI.

SUDBURY RIVER AT FRAMINGHAM. DRAINAGE AREA, 75 SQUARE MILES.

Monthly flows in second feet per square mile arranged chronologically.

Year	Jan.	Feb.	Mch.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1875	0.159	2.315	2.482	4.718	1.838	1.346	0.497	0.612	0.321	1.000	2.015	0.903
1876	0.995	2.116	6.862	5.094	1.761	0.343	0.283	0.627	0.285	0.361	1.683	0.702
1877	1.019	1.469	7.448	3.703	2.153	0.924	0.312	0.187	0.092	0.977	2.193	1.995
1878	2.800	3.814	5.426	2.516	2.158	0.782	0.199	0.736	0.249	0.799	2.619	4.916
1879	1.083	2.647	3.605	4.821	1.723	0.640	0.243	0.611	0.218	0.109	0.318	0.716
1880	1.733	2.765	2.126	1.808	0.796	0.271	0.273	0.184	0.124	0.157	0.318	0.271
1881	0.642	2.392	6.195	2.392	1.493	2.070	0.428	0.229	0.305	0.287	0.611	1.199
1882	1.920	3.718	4.392	1.342	1.998	0.818	0.133	0.086	0.474	0.463	0.324	0.487
1883	0.518	1.598	2.492	2.088	1.450	0.464	0.178	0.122	0.141	0.288	0.317	0.299
1884	1.540	4.397	5.857	4.415	1.594	0.644	0.346	0.397	0.068	0.129	0.271	1.431
1885	1.919	2.095	2.433	2.808	2.067	0.659	0.096	0.372	0.187	0.519	1.822	1.816
1886	2.260	7.428	3.185	3.013	1.114	0.314	0.179	0.146	0.182	0.225	1.041	1.578
1887	4.006	4.377	4.437	4.053	1.561	0.640	0.178	0.331	0.172	0.294	0.570	0.995
1888	1.629	3.011	5.009	4.093	2.526	0.652	0.182	0.587	1.786	3.093	4.267	4.708
1889	4.305	1.850	2.071	2.182	1.361	1.011	0.980	2.216	1.274	1.903	3.003	3.467
1890	1.941	2.366	5.636	2.900	2.114	0.878	0.166	0.204	0.708	3.515	1.879	1.541
1891	4.669	5.393	6.889	3.708	0.902	0.639	0.231	0.252	0.314	0.325	0.472	0.842
1892	2.893	1.459	3.024	1.347	1.948	0.662	0.331	0.433	0.354	0.195	1.088	0.750
1893	0.671	2.386	5.020	3.287	4.460	0.681	0.244	0.280	0.167	0.343	0.494	1.242
1894	1.082	1.533	3.462	2.537	1.299	0.648	0.249	0.323	0.232	0.579	1.293	1.108
1895	1.600	0.837	3.728	3.901	0.984	0.270	0.357	0.354	0.138	2.133	4.296	2.767
1896	1.677	4.140	5.937	2.311	0.557	0.617	0.147	0.088	0.600	0.916	1.019	1.016
1897	1.307	1.651	3.968	2.290	1.416	1.488	1.018	0.914	0.282	0.145	1.406	2.450
1898	2.534	4.675	4.028	2.829	1.928	0.820	0.357	1.713	0.571	1.795	3.072	2.783
1899	3.540	2.136	6.505	3.900	0.791	0.102	0.029	0.054	0.145	0.179	0.470	0.340
1900	1.228	5.879	5.653	2.088	2.030	0.489	0.028	0.053	0.101	0.288	1.036	1.696
1901	0.676	0.464	4.262	6.504	4.570	1.165	0.473	0.656	0.472	0.637	0.733	4.179
1902	2.728	2.590	6.497	2.916	1.149	0.469	0.101	0.208	0.276	0.782	0.688	2.753
1903	2.685	3.526	5.344	3.498	0.542	3.075	0.689	0.475	0.201	0.761	0.561	0.901
1904	0.738	1.365	4.640	5.096	2.699	0.648	0.096	0.262	0.614	0.295	0.447	0.417
1905	2.182	0.510	3.864	2.543	0.460	0.723	0.275	0.177	1.928	0.245	0.431	1.373
1906	1.745	1.610	3.727	3.015	1.638	1.093	0.615	0.279	0.030	0.466	0.747	1.019
Average	1.888	2.766	4.569	3.241	1.721	0.814	0.308	0.436	0.407	0.756	1.297	1.646

In this and the two following pages, for August, 1899, and July and August, 1900, also the first three numbers under column 1 on p. 53, the flow was minus.

TABLE VII.

SUDBURY RIVER AT FRAMINGHAM. DRAINAGE AREA, 75 SQUARE MILES.

Monthly flows in second feet per square mile arranged in order of magnitude for each year.

Year	1	2	3	4	5	6	7	8	9	10	11	12
1875	0.159	0.321	0.497	0.612	0.903	1.000	1.346	1.838	2.015	2.315	2.422	4.715
1876	0.283	0.285	0.343	0.361	0.627	0.702	0.995	1.683	1.761	2.116	5.094	6.862
1877	0.092	0.187	0.312	0.924	0.977	1.019	1.469	1.995	2.153	2.193	3.703	7.448
1878	0.199	0.249	0.736	0.782	0.799	2.158	2.516	2.619	2.800	3.814	4.916	5.426
1879	0.109	0.218	0.243	0.318	0.611	0.640	0.716	1.083	1.723	2.647	3.605	4.821
1880	0.124	0.157	0.184	0.271	0.271	0.273	0.318	0.796	1.733	1.808	2.126	2.705
1881	0.229	0.287	0.305	0.428	0.611	0.642	1.199	1.493	2.070	2.392	2.392	6.195
1882	0.086	0.133	0.324	0.463	0.474	0.487	0.818	1.342	1.920	1.998	3.718	4.392
1883	0.122	0.141	0.178	0.288	0.299	0.317	0.464	0.518	1.450	1.598	2.088	2.492
1884	0.068	0.129	0.271	0.346	0.397	0.644	1.431	1.540	1.594	4.397	4.415	5.857
1885	0.096	0.187	0.372	0.519	0.659	1.816	1.822	1.910	2.067	2.095	2.433	2.808
1886	0.146	0.179	0.182	0.225	0.314	1.041	1.114	1.578	2.260	3.013	3.185	7.428
1887	0.172	0.178	0.294	0.331	0.570	0.640	0.995	1.561	4.006	4.053	4.377	4.437
1888	0.182	0.587	0.652	1.629	1.786	2.526	3.011	3.093	4.093	4.267	4.708	5.009
1889	0.980	1.011	1.274	1.361	1.850	1.903	2.071	2.182	2.216	3.003	3.467	4.305
1890	0.166	0.204	0.708	0.878	1.541	1.879	1.941	2.114	2.366	2.900	3.515	5.636
1891	0.231	0.252	0.314	0.325	0.472	0.639	0.842	0.902	3.708	4.669	5.393	6.889
1892	0.195	0.331	0.354	0.433	0.662	0.750	1.088	1.347	1.459	1.948	2.893	3.024
1893	0.167	0.244	0.289	0.343	0.494	0.671	0.681	1.242	2.386	3.287	4.460	5.020
1894	0.232	0.249	0.323	0.579	0.648	1.082	1.108	1.293	1.299	1.533	2.537	3.462
1895	0.138	0.270	0.354	0.357	0.837	0.984	1.600	2.133	2.767	3.728	5.901	4.296
1896	0.088	0.147	0.557	0.600	0.617	0.916	1.016	1.019	1.677	2.311	4.140	5.937
1897	0.145	0.282	0.914	1.018	1.307	1.406	1.416	1.488	1.651	2.290	2.450	3.968
1898	0.357	0.571	0.820	1.713	1.795	1.928	2.534	2.783	2.829	3.072	4.028	4.675
1899	-0.054	0.029	0.102	0.145	0.179	0.349	0.470	0.791	2.136	3.540	3.900	6.505
1900	-0.053	-0.028	0.101	0.288	0.489	1.036	1.228	1.696	2.030	2.088	5.653	5.879
1901	0.464	0.472	0.473	0.637	0.656	0.676	0.733	1.165	4.179	4.262	4.570	6.504
1902	0.101	0.208	0.276	0.469	0.688	0.782	1.149	2.590	2.728	2.753	2.916	6.497
1903	0.201	0.475	0.542	0.561	0.689	0.761	0.901	2.685	3.075	3.498	3.526	5.344
1904	0.096	0.262	0.295	0.417	0.447	0.614	0.648	0.738	1.365	2.699	4.640	5.096
1905	0.177	0.245	0.275	0.431	0.460	0.510	0.723	1.373	1.928	2.182	2.543	3.864
1906	0.030	0.279	0.466	0.615	0.747	1.019	1.093	1.610	1.638	1.745	3.015	3.727
Average	.179	.273	.416	.583	.746	.994	1.233	1.631	2.284	2.819	3.650	5.040

TABLE VIII.

SUDBURY RIVER AT FRAMINGHAM. DRAINAGE AREA, 75 SQUARE MILES.

Monthly flows in second feet per square mile arranged in order of magnitude of whole term.

1	2	3	4	5	6	7	8	9	10	11	12
0.054	0.178	0.279	0.361	0.579	0.736	1.019	1.533	1.928	2.433	3.093	4.397
0.053	0.179	0.280	0.372	0.587	0.738	1.036	1.540	1.941	2.450	3.185	4.415
0.028	0.179	0.282	0.397	0.600	0.747	1.041	1.541	1.948	2.482	3.287	4.437
0.029	0.182	0.283	0.417	0.611	0.750	1.082	1.561	1.995	2.492	3.462	4.460
0.030	0.182	0.285	0.428	0.611	0.761	1.083	1.578	1.998	2.516	3.467	4.570
0.068	0.184	0.287	0.431	0.612	0.782	1.088	1.594	2.015	2.526	3.498	4.640
0.086	0.187	0.288	0.433	0.614	0.782	1.093	1.598	2.030	2.534	3.515	4.669
0.088	0.187	0.288	0.447	0.615	0.791	1.108	1.600	2.067	2.537	3.526	4.675
0.092	0.195	0.294	0.460	0.617	0.796	1.114	1.610	2.070	2.543	3.540	4.708
0.096	0.199	0.295	0.463	0.627	0.799	1.149	1.629	2.071	2.590	3.605	4.718
0.096	0.201	0.299	0.464	0.637	0.818	1.165	1.638	2.088	2.619	3.703	4.821
0.101	0.204	0.305	0.464	0.639	0.820	1.199	1.651	2.088	2.647	3.708	4.916
0.101	0.208	0.312	0.466	0.640	0.837	1.228	1.677	2.095	2.685	3.718	5.009
0.102	0.218	0.314	0.469	0.640	0.842	1.242	1.683	2.114	2.699	3.727	5.020
0.109	0.225	0.314	0.470	0.642	0.878	1.274	1.696	2.116	2.728	3.728	5.094
0.122	0.229	0.317	0.472	0.644	0.901	1.293	1.713	2.126	2.753	3.814	5.096
0.124	0.231	0.318	0.472	0.648	0.902	1.299	1.723	2.133	2.765	3.864	5.344
0.129	0.232	0.318	0.473	0.648	0.903	1.307	1.733	2.136	2.767	3.900	5.393
0.133	0.243	0.321	0.474	0.652	0.914	1.342	1.745	2.153	2.783	3.901	5.426
0.138	0.244	0.323	0.475	0.656	0.916	1.346	1.761	2.158	2.800	3.968	5.636
0.141	0.245	0.324	0.487	0.659	0.924	1.347	1.786	2.182	2.808	4.006	5.653
0.145	0.249	0.325	0.489	0.662	0.977	1.361	1.795	2.182	2.829	4.028	5.857
0.145	0.249	0.331	0.494	0.671	0.980	1.365	1.808	2.193	2.893	4.053	5.879
0.146	0.252	0.331	0.497	0.676	0.984	1.373	1.816	2.216	2.900	4.093	5.937
0.147	0.262	0.340	0.510	0.681	0.995	1.406	1.822	2.260	2.916	4.140	6.195
0.157	0.270	0.343	0.518	0.688	0.995	1.416	1.838	2.290	3.003	4.179	6.497
0.159	0.271	0.343	0.519	0.689	1.000	1.431	1.850	2.311	3.011	4.262	6.504
0.166	0.271	0.346	0.542	0.702	1.011	1.450	1.879	2.315	3.013	4.267	6.505
0.167	0.271	0.354	0.557	0.708	1.016	1.459	1.903	2.366	3.015	4.296	6.862
0.172	0.273	0.354	0.561	0.716	1.018	1.469	1.910	2.386	3.024	4.305	6.889
0.177	0.275	0.357	0.570	0.723	1.019	1.488	1.920	2.392	3.072	4.377	7.428
0.178	0.276	0.357	0.571	0.733	1.019	1.493	1.928	2.392	3.075	4.392	7.448
0.107	0.227	0.316	0.476	0.651	0.886	1.268	1.721	2.149	2.747	3.831	5.472

See note under Table VI on p. 51.

TABLE IX.

SOUTH BRANCH NASHUA RIVER AT CLINTON. 119 SQUARE MILES.

Monthly flows in second feet per square mile arranged chronologically.

	Jan.	Feb.	Mch.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1897	1.232	1.440	4.270	2.525	1.800	1.828	2.231	1.386	.528	.377	1.984	3.521
1898	2.418	2.530	4.778	3.137	2.151	1.281	.514	2.049	1.045	2.334	3.358	3.189
1899	3.236	1.687	4.295	5.224	1.344	.869	.548	.365	.387	.379	.665	.555
1900	1.232	6.271	5.759	2.444	2.139	.894	.336	.304	.197	.437	1.354	2.429
1901	.803	.551	4.205	7.711	4.222	1.525	.738	.792	.495	1.001	.799	5.002
1902	2.579	2.168	6.176	3.341	1.595	.635	.452	.459	.372	1.471	.982	2.859
1903	1.957	3.300	5.297	3.463	.880	3.297	.966	.734	.580	1.065	.981	1.476
1904	1.020	1.434	4.653	4.617	2.317	1.179	.769	.549	.764	.538	.530	.680
1905	1.959	.700	4.648	2.502	.688	.838	.565	.497	1.900	.567	.684	1.578
1906	1.757	1.588	2.878	3.263	2.371	1.831	1.127	.915	.428	.820	1.160	1.229
	1.819	2.167	4.696	3.823	1.951	1.418	.825	.805	.670	.899	1.250	2.252

TABLE X.

SOUTH BRANCH NASHUA RIVER AT CLINTON. 119 SQUARE MILES.

Monthly flows in second feet per square mile arranged in order of magnitude by years.

	1	2	3	4	5	6	7	8	9	10	11	12
1897	.377	.528	1.232	1.386	1.440	1.800	1.828	1.984	2.231	2.525	3.521	4.270
1898	.514	1.045	1.281	2.049	2.151	2.334	2.418	2.530	3.137	3.189	3.358	4.778
1899	.365	.379	.387	.548	.555	.665	.869	1.344	1.687	3.236	4.295	5.224
1900	.197	.304	.336	.437	.894	1.232	1.354	2.139	2.429	2.444	5.759	6.271
1901	.495	.551	.738	.792	.799	.803	1.001	1.525	4.205	4.222	5.002	7.711
1902	.372	.452	.459	.635	.982	1.471	1.595	2.168	2.579	2.859	3.341	6.176
1903	.580	.734	.880	.966	.981	1.065	1.476	1.957	3.297	3.300	3.463	5.297
1904	.530	.538	.549	.680	.764	.769	1.020	1.179	1.434	2.317	4.617	4.653
1905	.497	.565	.567	.684	.688	.700	.838	1.575	1.900	1.959	2.502	4.648
1906	.428	.820	.915	1.127	1.160	1.229	1.588	1.751	1.831	2.371	2.878	3.263
	.436	.592	.734	.930	1.041	1.207	1.399	1.815	2.473	2.842	3.874	5.229

TABLE XI.

SOUTH BRANCH NASHUA RIVER AT CLINTON.

Monthly flows in second feet per square mile arranged in order of magnitude of whole term regardless of the years.

	1	2	3	4	5	6	7	8	9	10	11	12
1	.197	.452	.551	.700	.869	1.065	1.386	1.751	2.151	2.525	3.300	4.648
2	.304	.459	.555	.734	.880	1.127	1.434	1.800	2.168	2.530	3.341	4.653
3	.336	.495	.565	.738	.894	1.160	1.440	1.828	2.231	2.579	3.358	4.778
4	.365	.497	.567	.764	.915	1.179	1.471	1.831	2.317	2.859	3.463	5.002
5	.372	.514	.580	.769	.966	1.229	1.476	1.900	2.334	2.878	3.521	5.224
6	.377	.528	.635	.792	.981	1.232	1.525	1.957	2.371	3.137	4.205	5.297
7	.379	.530	.665	.799	.982	1.232	1.575	1.959	2.418	3.189	4.222	5.759
8	.387	.538	.680	.803	1.001	1.281	1.588	1.984	2.429	3.236	4.270	6.176
9	.428	.548	.684	.820	1.020	1.344	1.595	2.049	2.444	3.263	4.295	6.271
10	.437	.549	.688	.838	1.045	1.354	1.687	2.139	2.502	3.297	4.617	7.711
	.358	.511	.617	.776	.955	1.220	1.518	1.920	2.336	2.949	3.859	5.552

TABLE XII.

NASHUA RIVER AT CLINTON. 119 SQUARE MILES.

Comparison of Available Flow Averaged by Three Different Methods.

Chronologically.			Order of Magnitude by years.			Order of Magnitude of whole term.		
Month.	Flow and Development.	Flow Available.	No.	Flow and Development.	Flow Available.	No.	Flow and Development.	Flow Available.
Sept.	.669	.669	1	.436	.436	1	.358	.358
Aug.	.805	.794	2	.592	.579	2	.511	.498
July	.824	.809	3	.734	.697	3	.617	.587
Oct.	.899	.866	4	.930	.844	4	.776	.706
Nov.	1.250	1.100	5	1.041	.918	5	.955	.825
June	1.418	1.198	6	1.207	1.015	6	1.220	.980
Jan.	1.819	1.398	7	1.399	1.111	7	1.518	1.129
May	1.951	1.453	8	1.815	1.285	8	1.920	1.296
Feb.	2.167	1.525	9	2.473	1.504	9	2.337	1.436
Dec.	2.251	1.546	10	2.842	1.596	10	2.949	1.580
April	3.823	1.808	11	3.874	1.768	11	3.859	1.740
March	4.696	1.881	12	5.229	1.881	12	5.552	1.881

TABLE XIII.

MERRIMAC RIVER AT LAWRENCE. DRAINAGE AREA, 4,553 SQUARE MILES.

1880 to 1900. Weekly data arranged in order of magnitude for full term.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1.	.271	.386	.414	.434	.450	.476	.491	.500	.515	.534	.548	.565	.581	.602	.615	.640	.663	.689
2.	.284	.387	.415	.434	.461	.477	.491	.501	.516	.534	.549	.565	.581	.602	.617	.641	.663	.692
3.	.325	.390	.415	.437	.461	.477	.492	.501	.517	.535	.550	.566	.582	.604	.618	.642	.665	.692
4.	.335	.393	.416	.437	.461	.479	.492	.502	.519	.536	.551	.568	.583	.604	.619	.644	.665	.693
5.	.339	.394	.418	.439	.463	.480	.493	.505	.519	.536	.553	.569	.584	.604	.621	.644	.666	.694
6.	.342	.396	.419	.440	.465	.482	.493	.505	.521	.536	.553	.570	.586	.605	.624	.645	.668	.695
7.	.344	.396	.420	.440	.466	.482	.493	.505	.521	.536	.553	.570	.586	.607	.624	.645	.669	.699
8.	.345	.397	.422	.440	.466	.482	.494	.506	.524	.536	.555	.571	.591	.607	.625	.648	.672	.701
9.	.350	.399	.422	.441	.466	.483	.494	.508	.524	.539	.555	.573	.597	.607	.626	.652	.673	.704
10.	.364	.401	.423	.444	.467	.487	.494	.508	.525	.541	.555	.574	.597	.608	.626	.654	.676	.706
11.	.368	.403	.423	.446	.467	.487	.495	.508	.525	.541	.556	.574	.598	.609	.629	.655	.677	.706
12.	.369	.405	.423	.447	.468	.488	.495	.508	.526	.542	.556	.575	.600	.613	.630	.655	.679	.707
13.	.372	.405	.424	.449	.469	.489	.496	.512	.529	.543	.557	.575	.600	.613	.634	.656	.681	.707
14.	.374	.406	.430	.451	.469	.489	.498	.513	.530	.544	.557	.578	.601	.614	.635	.657	.685	.710
15.	.380	.406	.431	.455	.470	.490	.498	.514	.532	.546	.557	.578	.601	.614	.636	.659	.686	.711
16.	.383	.409	.432	.457	.470	.490	.499	.514	.533	.546	.560	.578	.601	.614	.636	.660	.687	.712
17.	.385	.411	.432	.458	.472	.491	.500	.515	.533	.548	.564	.579	.601	.615	.639	.660	.688	.715
Av.	.349	.399	.422	.444	.466	.484	.494	.507	.524	.540	.555	.572	.591	.608	.627	.650	.674	.702

TABLE XIII—Continued.
MERRIMAC RIVER AT LAWRENCE. DRAINAGE AREA, 4,553 SQUARE MILES.
1890 to 1906. Weekly data arranged in order of magnitude for full term.

	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
1.	.716	.743	.763	.790	.826	.865	.899	.934	.991	1.045	1.114	1.160	1.231	1.300	1.355	1.420	1.485	1.577
2.	.720	.743	.764	.792	.837	.865	.900	.935	.994	1.046	1.118	1.161	1.234	1.302	1.359	1.431	1.486	1.577
3.	.721	.744	.766	.794	.839	.867	.902	.947	.999	1.053	1.121	1.161	1.235	1.307	1.367	1.423	1.486	1.580
4.	.721	.744	.772	.795	.841	.869	.902	.951	1.000	1.054	1.123	1.163	1.244	1.313	1.367	1.439	1.490	1.583
5.	.722	.745	.773	.795	.845	.870	.903	.953	1.001	1.067	1.126	1.169	1.249	1.313	1.370	1.430	1.493	1.590
6.	.722	.745	.773	.795	.847	.874	.903	.966	1.004	1.073	1.127	1.173	1.251	1.316	1.375	1.433	1.502	1.590
7.	.724	.751	.774	.800	.848	.878	.910	.968	1.007	1.079	1.130	1.181	1.252	1.316	1.387	1.438	1.504	1.592
8.	.726	.752	.775	.802	.849	.879	.910	.971	1.009	1.083	1.135	1.195	1.260	1.319	1.394	1.442	1.517	1.595
9.	.726	.753	.780	.802	.853	.886	.911	.972	1.015	1.086	1.138	1.197	1.268	1.319	1.394	1.443	1.519	1.596
10.	.727	.755	.780	.807	.855	.886	.913	.972	1.017	1.092	1.142	1.198	1.272	1.319	1.398	1.444	1.530	1.597
11.	.729	.756	.781	.809	.858	.888	.915	.973	1.025	1.095	1.142	1.204	1.275	1.319	1.400	1.452	1.532	1.600
12.	.729	.756	.781	.809	.859	.888	.925	.974	1.029	1.098	1.143	1.204	1.287	1.327	1.412	1.457	1.536	1.604
13.	.730	.756	.783	.809	.859	.888	.925	.977	1.034	1.098	1.144	1.208	1.291	1.328	1.413	1.458	1.545	1.608
14.	.731	.757	.783	.810	.861	.889	.928	.980	1.035	1.101	1.148	1.210	1.292	1.333	1.414	1.477	1.545	1.608
15.	.731	.758	.784	.813	.863	.891	.928	.985	1.036	1.108	1.148	1.211	1.295	1.335	1.414	1.477	1.548	1.615
16.	.733	.759	.788	.821	.864	.894	.928	.989	1.039	1.110	1.149	1.218	1.296	1.344	1.416	1.477	1.548	1.619
17.	.740	.760	.788	.825	.864	.895	.929	.991	1.041	1.110	1.157	1.222	1.296	1.353	1.417	1.485	1.569	1.622
Av.	.726	.752	.777	.804	.851	.881	.914	.961	1.016	1.082	1.136	1.190	1.266	1.321	1.391	1.447	1.520	1.597

TABLE XIII—*Concluded.*

MERRIMAC RIVER AT LAWRENCE. DRAINAGE AREA, 4,553 SQUARE MILES.

1890 to 1906. Weekly data arranged in order of magnitude for full term.

	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52
1.	1.626	1.785	1.895	2.017	2.128	2.280	2.431	2.565	2.786	3.017	3.323	3.639	4.199	4.519	5.088	5.765
2.	1.634	1.802	1.992	2.019	2.133	2.283	2.432	2.568	2.823	3.053	3.356	3.661	4.217	4.562	5.095	5.908
3.	1.634	1.804	1.993	2.026	2.169	2.289	2.440	2.571	2.830	3.084	3.384	3.681	4.244	4.595	5.111	5.941
4.	1.639	1.825	1.928	2.048	2.173	2.294	2.443	2.598	2.832	3.092	3.389	3.683	4.261	4.608	5.122	6.310
5.	1.686	1.831	1.929	2.049	2.202	2.319	2.457	2.619	2.853	3.096	3.415	3.690	4.278	4.636	5.168	6.364
6.	1.687	1.833	1.929	2.050	2.203	2.322	2.461	2.631	2.865	3.103	3.424	3.747	4.291	4.637	5.242	6.426
7.	1.697	1.846	1.935	2.055	2.204	2.350	2.472	2.676	2.891	3.119	3.433	3.762	4.300	4.681	5.267	6.436
8.	1.701	1.851	1.941	2.056	2.205	2.371	2.473	2.687	2.915	3.123	3.445	3.835	4.320	4.701	5.270	6.470
9.	1.702	1.858	1.943	2.060	2.217	2.372	2.486	2.701	2.930	3.124	3.446	3.894	4.339	4.718	5.274	6.767
10.	1.708	1.861	1.946	2.075	2.226	2.376	2.502	2.714	2.953	3.134	3.454	3.942	4.342	4.723	5.307	7.260
11.	1.716	1.874	1.969	2.077	2.231	2.377	2.507	2.723	2.955	3.147	3.476	3.944	4.375	4.723	5.335	7.361
12.	1.718	1.883	1.969	2.078	2.231	2.388	2.508	2.726	2.982	3.148	3.478	3.950	4.378	4.734	5.340	7.891
13.	1.725	1.885	1.981	2.091	2.239	2.391	2.509	2.729	2.986	3.150	3.481	3.966	4.468	4.837	5.387	7.900
14.	1.734	1.889	1.990	2.098	2.246	2.392	2.530	2.735	3.005	3.193	3.493	3.969	4.469	4.884	5.392	8.237
15.	1.759	1.890	1.993	2.104	2.254	2.394	2.531	2.746	3.014	3.231	3.510	3.981	4.471	5.007	5.530	8.622
16.	1.764	1.892	2.005	2.115	2.259	2.400	2.539	2.751	3.014	3.234	3.520	4.060	4.475	5.044	5.585	9.036
17.	1.781	1.895	2.014	2.116	2.270	2.406	2.558	2.781	3.015	3.303	3.529	4.168	4.511	5.061	5.725	9.043
Av.	1.701	1.853	1.951	2.067	2.211	2.353	2.487	2.678	2.921	3.138	3.444	3.857	4.349	4.744	5.308	7.161

TABLE XIV.
MERRIMAC AT LAWRENCE. 1890 TO 1906.

Development	Average Available	Weeks		Available per ct. of Development.
		Short	Full	
0.3	0.300	0	52	100
0.4	0.399	2	50	100
0.5	0.492	7	45	98
0.6	0.572	13	39	95
0.7	0.642	17	35	92
0.8	0.705	21	31	88
0.9	0.762	24	28	85
1.0	0.813	26	26	81
1.1	0.861	28	24	78
1.2	0.906	30	22	76
1.3	0.947	31	21	73
1.4	0.986	33	19	70
1.5	1.022	34	18	68
1.6	1.055	36	16	66
1.7	1.085	36	16	64
1.8	1.114	37	15	62
1.9	1.142	38	14	60
2.0	1.168	39	13	58
2.1	1.193	40	12	57
2.2	1.215	41	11	55
2.3	1.236	41	11	54
2.4	1.256	42	10	52
2.5	1.275	43	9	51
2.6	1.292	43	9	50
2.7	1.309	44	8	48
2.8	1.325	44	8	47
2.9	1.340	44	8	46
3.0	1.354	45	7	45
3.1	1.367	45	7	44
3.2	1.380	46	6	43
3.3	1.391	46	6	42
3.4	1.400	46	6	41
3.5	1.413	47	5	40
3.6	1.423	47	5	39
3.7	1.432	47	5	38
3.8	1.442	47	5	37
3.9	1.451	48	4	37
4.0	1.458	48	4	36
4.1	1.466	48	4	36
4.2	1.474	48	4	35
4.3	1.482	48	4	35
4.4	1.488	49	3	34
4.5	1.494	49	3	33
4.6	1.500	49	3	33
4.7	1.506	49	3	32
4.8	1.510	50	2	32
4.9	1.514	50	2	31
5.0	1.518	50	2	30

TABLE XV.

CONNECTICUT RIVER AT HOLYOKE, MASS.

C. F. S.=Cubic feet per second on the watershed of 8,660 square miles.

C. F. S. S. M.=Cubic feet per second per square mile.

Table prepared by C. F. Chandler and S. B. Pal

C.F.S.	C. F. S. S. M.	1851	1882	1883	1884	1885	1886	1887	1888	1889	1890
1,600	0.1847	0	0	0	0	0	0	0	0	0	0
1,650	0.1905	0	0	0	0	0	0	0	0	0	0
1,700	0.1963	0	0	0	0	0	0	0	0	0	0
1,750	0.2021	0	0	0	0	0	0	0	0	0	0
1,800	0.2078	0	0	0	1	0	0	0	0	0	0
1,850	0.2136	0	0	0	0	0	0	0	0	0	0
1,900	0.2194	0	0	0	0	0	0	0	0	0	0
1,950	0.2252	0	0	0	7	5	0	0	0	0	0
2,000	0.2309	0	0	0	0	8	0	0	0	0	0
2,050	0.2367	0	0	0	0	8	0	0	0	0	0
2,100	0.2425	0	0	0	0	8	0	0	0	0	0
2,150	0.2483	0	0	0	7	15	0	0	0	0	0
2,200	0.2540	0	0	0	0	15	0	0	0	0	0
2,250	0.2598	0	0	0	7	22	0	0	0	0	0
2,300	0.2656	0	0	0	7	29	0	0	0	0	0
2,350	0.2714	0	0	2	2	31	0	0	0	0	0
2,400	0.2771	0	0	8	10	2	33	0	0	0	0
2,450	0.2829	0	0	2	12	1	34	0	0	0	0
2,500	0.2887	0	0	2	14	2	36	0	0	0	0
2,550	0.2945	0	0	3	17	0	36	0	0	0	0
2,600	0.3002	0	0	1	18	3	39	0	0	0	0
2,650	0.3060	0	0	0	18	1	40	0	0	0	0
2,700	0.3118	12	12	0	18	1	41	7	16	0	0
2,750	0.3176	0	12	2	20	0	47	0	16	0	0
2,800	0.3233	0	12	1	21	7	54	7	23	0	0
2,850	0.3291	8	20	11	32	8	62	0	23	0	0
2,900	0.3349	0	20	2	34	5	67	1	24	0	0
2,950	0.3407	53	73	5	39	8	75	2	26	2	2
3,000	0.3464	9	82	7	46	3	78	2	28	1	3
3,050	0.3522	7	89	5	51	5	83	7	35	1	4
3,100	0.3580	10	99	1	52	4	87	2	37	2	6
3,150	0.3638	0	99	0	52	0	87	0	37	0	6
3,200	0.3695	0	99	7	59	7	94	6	43	1	7
3,250	0.3753	0	99	3	62	4	98	0	43	0	7
3,300	0.3811	1	100	2	64	6	104	0	43	2	9
3,350	0.3869	0	100	1	65	7	111	0	43	0	9
3,400	0.3926	1	101	7	72	11	122	0	43	1	10
3,450	0.3984	2	103	7	79	7	129	0	43	0	10
3,500	0.4042	2	105	9	88	7	136	8	51	1	11
3,550	0.4100	0	105	5	93	2	138	0	51	4	15
3,600	0.4157	12	117	6	99	8	146	8	59	1	16
3,650	0.4215	0	117	8	107	12	158	6	65	2	18
3,700	0.4273	7	124	8	115	3	161	1	66	3	21
3,750	0.4331	3	127	7	122	5	166	0	66	1	22
3,800	0.4388	2	129	2	124	3	169	2	68	2	24
3,850	0.4446	3	132	1	125	3	172	0	68	3	27
3,900	0.4504	0	132	0	125	4	176	2	70	1	28
3,950	0.4562	1	133	0	125	1	177	2	72	1	29
4,000	0.4619	1	134	1	126	1	178	6	78	0	29
4,050	0.4677	1	135	2	128	4	182	3	81	2	31
4,100	0.4735	3	138	2	130	2	184	3	84	2	33
4,150	0.4793	2	140	2	132	1	185	4	88	5	38
4,200	0.4850	1	141	2	134	0	185	1	89	0	38
4,250	0.4908	0	141	2	136	1	186	2	91	3	41
4,300	0.4966	1	142	2	138	1	187	1	92	5	46
4,350	0.5024	1	143	1	139	2	189	5	97	1	47
4,400	0.5081	1	144	4	143	4	193	3	100	1	48
4,450	0.5137	0	144	0	143	0	193	0	100	0	48
4,500	0.5197	0	144	1	144	1	194	1	100	1	49
4,550	0.5255	1	145	0	144	1	195	0	101	0	49
4,600	0.5312	0	145	0	144	2	197	2	103	2	51
4,650	0.5370	1	146	0	144	4	201	1	104	2	53
4,700	0.5428	1	147	0	144	3	204	1	105	1	54
4,750	0.5486	3	150	2	146	1	205	0	105	2	56
4,800	0.5543	0	150	2	148	2	207	1	106	1	57

CONNECTICUT RIVER AT HOLYOKE, MASS.

Second column under each year gives number of days each flow was not exceeded.

Norwich, Conn., from data by A. F. Sickman, Holyoke, Mass.

1892	1893	1894	1895	1896	1897	1898	1899	Total.	Average.	C. F. S.	C. F. S. S. M.
0	0	0	7	7	0	0	0	7	7.0	0.4	0.1847
0	0	2	0	7	0	0	0	3	10.0	0.6	0.1905
0	0	1	3	7	0	0	0	1	11.0	0.6	0.1963
0	0	0	3	7	0	0	0	0	11.0	0.6	0.2021
0	0	0	3	1	8	0	0	2	13.0	0.7	0.2078
0	0	0	3	8	0	0	0	0	13.0	0.7	0.2136
0	0	0	3	7	15	0	0	8	21.0	1.1	0.2174
0	0	0	3	0	15	0	0	7	28.0	1.5	0.2252
0	0	0	3	0	15	0	0	0	28.0	1.5	0.2309
0	0	0	3	2	17	0	0	6	34.0	1.8	0.2367
0	0	0	3	0	17	0	0	9	43.0	2.3	0.2425
0	0	0	3	0	17	0	0	8	51.0	2.7	0.2483
0	0	0	3	0	17	0	0	0	51.0	2.7	0.2540
0	0	0	3	2	19	0	0	6	67.0	3.5	0.2598
0	0	0	3	7	26	0	0	6	86.0	4.5	0.2656
0	0	0	3	7	33	0	0	14	116.0	6.1	0.2714
0	0	0	3	1	34	0	0	7	135.0	7.1	0.2771
0	0	1	4	7	41	0	0	27	149.0	7.8	0.2829
6	0	0	4	0	41	2	0	9	171.2	9.0	0.2887
1	1	2	6	2	43	0	2	22	193.1	10.2	0.2945
0	1	4	10	0	43	2	4	43	205.0	10.8	0.3002
0	1	1	11	2	45	0	4	43	223.0	11.7	0.3060
0	1	1	12	0	45	9	13	8	275.2	14.4	0.3118
1	2	1	13	4	49	0	13	0	299.1	15.7	0.3176
0	2	1	14	0	49	3	16	8	338.0	17.7	0.3233
1	3	2	16	2	51	8	23	0	389.2	20.4	0.3291
0	3	2	18	0	51	4	28	1	422.1	22.1	0.3349
2	5	1	19	3	54	13	41	1	528.5	27.7	0.3407
2	7	2	21	3	57	9	50	0	583.2	30.1	0.3464
0	7	6	27	4	61	9	59	0	629.2	33.0	0.3522
0	7	4	31	3	64	6	65	0	674.2	35.3	0.3580
0	7	0	31	0	64	4	79	0	703.1	36.8	0.3638
3	10	4	35	0	64	1	80	0	749.2	39.2	0.3695
0	10	9	44	0	64	5	85	0	789.2	41.3	0.3753
0	10	0	44	0	64	5	90	2	824.1	43.1	0.3811
0	10	2	46	5	69	4	94	2	859.1	44.9	0.3869
0	10	3	49	2	71	4	98	1	898.0	46.9	0.3926
1	11	2	51	2	73	1	99	2	940.2	49.1	0.3984
0	11	1	52	0	73	8	107	0	989.2	51.7	0.4042
0	11	0	52	2	75	6	113	0	1,030.2	53.9	0.4100
1	12	3	55	2	77	7	120	1	1,095.3	57.3	0.4157
1	13	3	58	0	77	1	121	4	1,146.2	60.0	0.4215
0	13	1	59	1	78	5	126	2	1,198.2	62.7	0.4273
0	13	8	67	0	78	0	126	3	1,241.2	65.0	0.4331
0	13	8	75	1	79	2	128	5	1,277.1	66.9	0.4388
0	13	3	78	1	80	2	130	0	1,304.1	68.3	0.4446
1	14	7	85	4	84	6	136	5	1,345.2	70.5	0.4504
0	14	3	88	2	86	2	138	0	1,368.1	71.7	0.4562
1	15	4	92	3	89	2	140	3	1,403.1	73.5	0.4619
0	15	4	96	3	92	3	143	1	1,434.1	75.1	0.4677
0	15	1	97	1	93	3	146	3	1,466.1	76.8	0.4735
2	17	3	100	1	94	0	146	4	1,501.1	78.6	0.4793
4	21	2	102	0	94	4	150	2	1,527.1	80.0	0.4850
4	25	5	107	2	96	1	151	3	1,559.1	81.7	0.4908
3	28	3	110	2	98	3	154	6	1,591.1	83.4	0.4966
4	32	5	115	1	99	3	157	2	1,627.1	85.3	0.5024
6	38	5	120	1	100	2	159	4	1,671.2	87.6	0.5081
2	40	1	121	4	104	0	159	4	1,692.1	88.7	0.5139
4	44	3	124	2	106	2	161	3	1,718.1	90.1	0.5197
2	46	3	127	2	108	4	165	4	1,745.1	91.5	0.5255
0	46	2	129	4	112	2	167	1	1,772.1	92.9	0.5312
3	49	4	133	2	114	0	167	4	1,804.1	94.6	0.5370
4	53	3	136	4	118	3	170	4	1,835.1	96.2	0.5428
1	54	1	137	6	124	5	175	2	1,867.1	97.9	0.5486
1	55	4	141	9	133	1	176	2	1,899.1	99.6	0.5544

TABLE XV.—Continued.

CONNECTICUT RIVER AT HOLYOKE, MASS.

C. F. S.=Cubic feet per second on the watershed of 8,660 square miles.

C. F. S. S. M.=Cubic feet per second per square mile.

Table prepared by C. E. Chandler and S. B. Palmer.

C.F.S.	C. F. S. S. M.	1881	1882	1883	1884	1885	1886	1887	1888	1889	1890	1891
4,850	0.5601	0 150	2 150	2 209	3 109	6 63	0 112	2 47	0 35	0 24	0 44	2 99
4,900	0.5659	0 150	3 153	2 211	4 113	1 64	1 113	0 47	2 37	1 25	0 44	0 69
4,950	0.5717	2 152	2 155	2 213	2 115	2 66	0 113	0 47	1 38	0 25	0 44	1 100
5,000	0.5774	2 154	2 157	4 217	1 116	3 69	0 113	0 47	0 38	0 25	0 44	3 105
5,050	0.5831	1 155	2 159	0 217	1 117	2 71	0 113	0 47	0 38	0 25	1 45	2 105
5,100	0.5899	1 156	1 160	0 217	2 119	4 75	1 114	0 47	0 38	0 25	2 47	4 105
5,150	0.5947	1 157	0 160	2 219	1 120	1 76	1 115	1 48	0 38	0 25	0 47	3 112
5,200	0.6004	4 161	0 160	0 219	3 123	0 76	0 115	0 48	0 38	1 26	2 49	1 113
5,250	0.6062	1 162	0 160	1 220	1 124	2 78	0 115	0 48	0 38	0 26	1 50	3 119
5,300	0.6120	0 162	0 160	0 220	2 126	1 79	0 115	2 50	4 42	1 27	2 52	1 117
5,350	0.6178	1 163	0 160	0 220	2 128	3 82	0 115	0 50	1 43	0 27	2 54	3 120
5,400	0.6235	1 164	2 162	1 221	1 129	3 85	0 115	1 51	0 43	0 27	1 55	1 121
5,450	0.6293	0 164	0 162	0 221	5 134	4 89	1 116	0 51	0 43	0 27	0 55	3 122
5,500	0.6351	2 166	0 162	0 221	1 135	2 91	1 117	1 52	1 44	0 27	0 55	0 124
5,550	0.6409	1 167	0 162	0 221	0 135	3 94	0 117	2 54	0 44	0 27	1 56	1 125
5,600	0.6466	1 168	3 165	0 221	3 138	2 96	0 117	0 54	0 44	1 28	0 56	2 127
5,650	0.6524	0 168	0 165	1 222	0 144	1 97	0 117	3 57	3 47	0 28	0 56	1 128
5,700	0.6582	1 169	1 166	1 223	4 148	2 99	0 117	1 58	1 48	0 28	0 56	1 129
5,750	0.6640	0 169	1 167	1 224	1 149	0 99	0 117	1 59	2 50	2 30	0 56	1 130
5,800	0.6697	0 169	0 167	1 225	0 149	2 101	1 118	0 59	2 52	2 32	1 57	0 131
5,850	0.6755	0 169	3 170	0 225	2 151	1 102	2 120	2 61	0 52	0 32	1 58	0 132
5,900	0.6813	1 170	1 171	0 225	1 152	1 103	0 120	0 61	1 53	1 33	0 58	1 133
5,950	0.6871	1 171	1 172	1 226	1 153	2 105	1 121	0 61	1 54	3 36	4 62	0 134
6,000	0.6928	1 172	0 172	2 228	1 154	1 106	0 121	1 62	1 55	0 36	0 62	4 135
6,050	0.6986	0 172	1 173	1 229	1 155	0 106	1 122	0 62	2 57	1 37	1 63	3 136
6,100	0.7044	1 173	0 173	0 229	2 157	1 107	1 123	4 66	0 57	0 37	0 63	2 137
6,150	0.7102	0 173	0 173	0 229	0 157	2 109	2 125	2 68	1 58	2 39	0 63	1 138
6,200	0.7159	0 173	1 174	0 229	2 159	1 110	1 126	3 71	0 58	0 39	1 64	1 139
6,250	0.7217	0 173	0 174	2 231	0 159	1 111	0 126	4 75	0 58	2 41	4 68	1 140
6,300	0.7275	1 174	0 174	1 232	0 159	3 114	0 126	1 76	3 61	2 43	1 69	0 141
6,350	0.7333	1 175	0 174	0 232	0 159	0 114	1 127	0 76	1 62	1 44	1 70	0 142
6,400	0.7390	0 175	3 177	0 232	0 159	1 115	0 127	1 77	3 65	0 44	1 71	3 143
6,450	0.7448	1 176	1 178	1 233	0 159	0 115	1 128	2 79	3 68	1 45	0 71	0 144
6,500	0.7506	1 177	1 179	1 234	1 160	4 119	0 128	2 81	1 69	2 47	1 72	2 145
6,550	0.7564	2 179	1 180	2 236	1 161	0 119	1 129	2 83	1 70	2 49	1 73	1 146
6,600	0.7621	2 181	3 183	2 238	0 161	1 120	2 131	3 86	1 71	1 50	2 75	0 147
6,650	0.7679	3 184	0 183	1 239	0 161	1 121	0 131	2 88	0 71	1 51	0 75	1 148
6,700	0.7737	2 186	0 183	0 239	2 163	5 126	1 132	2 90	2 73	0 51	0 75	0 149
6,750	0.7795	0 186	0 183	1 240	0 163	1 127	0 132	0 90	3 76	0 51	2 77	1 150
6,800	0.7852	3 189	0 183	1 241	0 163	2 129	3 135	1 91	1 77	0 51	0 77	2 151
6,850	0.7910	0 189	0 183	1 242	2 165	1 130	3 138	0 91	4 81	2 53	1 78	2 152
6,900	0.7968	0 189	0 183	0 242	1 166	0 130	0 138	0 91	0 81	3 56	0 78	1 153
6,950	0.8026	0 189	1 184	0 242	1 167	2 132	0 138	0 91	2 83	1 57	0 78	1 154
7,000	0.8083	0 189	1 185	1 243	1 168	0 132	0 138	0 91	5 88	2 59	1 79	0 155
7,050	0.8141	1 190	2 187	2 245	1 169	1 133	1 139	1 92	3 91	3 62	0 79	0 156
7,100	0.8199	1 191	1 188	0 245	0 169	1 134	1 140	0 92	3 94	1 63	4 83	0 157
7,150	0.8257	1 192	0 188	0 245	0 169	1 135	1 141	1 93	3 97	0 63	1 84	0 158
7,200	0.8314	0 192	0 188	1 246	1 170	1 136	2 143	2 95	1 98	2 65	1 85	2 159
7,250	0.8372	0 192	0 188	0 246	0 170	2 138	1 144	1 96	4 102	2 67	4 89	1 160
7,300	0.8430	1 193	1 189	0 246	2 172	0 138	1 145	3 99	3 105	3 70	1 90	1 161
7,350	0.8488	0 193	0 189	2 248	2 174	0 138	0 145	3 102	1 106	1 71	1 91	1 162
7,400	0.8545	2 195	0 189	1 249	1 175	2 140	3 148	2 104	2 108	1 72	0 91	1 163
7,450	0.8603	0 195	1 190	0 249	1 176	1 141	0 148	2 106	0 108	2 74	1 92	0 164
7,500	0.8661	1 196	2 192	1 250	2 178	3 144	2 150	2 108	0 108	1 75	0 92	2 165
7,550	0.8719	0 196	2 194	1 251	2 180	1 145	2 152	3 111	1 109	2 77	0 92	0 166
7,600	0.8776	1 197	0 194	1 252	1 181	0 145	1 153	4 115	1 110	0 77	0 92	2 167
7,650	0.8834	1 198	0 194	0 252	1 182	1 146	1 154	4 119	2 112	0 77	0 92	0 168
7,700	0.8892	0 198	0 194	2 254	1 183	3 149	0 154	2 121	1 113	2 79	0 92	1 169
7,750	0.8950	1 199	1 195	1 255	0 183	4 153	1 155	2 123	1 114	2 81	0 92	0 170
7,800	0.9007	1 200	0 195	0 255	0 183	3 156	3 158	1 124	0 114	0 81	0 92	0 171
7,850	0.9065	0 200	1 196	1 256	0 183	2 158	1 159	3 127	1 115	1 82	0 92	1 172
7,900	0.9123	1 201	0 196	0 256	1 184	2 160	0 159	3 130	2 117	1 83	2 94	0 173
7,950	0.9181	0 201	0 196	0 256	0 184	0 160	1 160	0 130	0 117	0 83	1 95	0 174
8,000	0.9238	0 201	0 196	0 256	0 184	2 162	2 162	0 130	2 119	2 85	1 96	0 175

TABLE XV.—*Concluded.*

CONNECTICUT RIVER AT HOLYOKE, MASS.

First column under each year is number of days each flow occurred.

Second column under each year gives number of days each flow was not exceeded.

Norwich, Conn., from data by A. F. Sickman, Holyoke, Mass.

	1892	1893	1894	1895	1896	1897	1898	1899	Total.	Average.	C.F.S.	C. F. S. S. M.	
1	56	2 143	3 136	3 179	2 106	3 79	2 59	2 134	35 1,934	1.8	101.4	4,850	0.5601
2	58	4 147	1 137	1 180	1 107	5 84	0 59	1 135	29 1,963	1.5	102.9	4,900	0.5659
2	60	2 149	3 140	2 182	0 107	4 88	0 59	1 136	26 1,989	1.4	104.3	4,950	0.5717
3	63	0 149	4 144	0 182	1 108	1 89	1 60	2 138	27 2,016	1.4	105.7	5,000	0.5774
2	65	2 151	5 149	1 183	2 110	1 90	3 63	2 140	27 2,043	1.4	107.1	5,050	0.5831
3	68	0 151	3 152	1 184	1 111	4 94	0 63	4 144	31 2,074	1.6	108.7	5,100	0.5889
2	70	1 152	3 155	3 187	1 112	1 95	0 63	6 150	27 2,101	1.4	110.1	5,150	0.5947
1	71	3 155	1 156	2 189	1 113	1 96	0 63	4 154	24 2,125	1.3	111.4	5,200	0.6004
3	74	4 159	4 160	1 190	2 115	1 97	0 63	4 158	28 2,153	1.5	112.9	5,250	0.6062
0	74	2 161	0 160	0 190	0 115	1 98	0 63	5 163	21 2,174	1.1	114.0	5,300	0.6120
1	75	0 161	3 163	0 190	2 117	0 98	1 64	4 167	23 2,197	1.2	115.2	5,350	0.6178
1	76	1 162	1 164	1 191	0 117	0 98	0 64	5 172	20 2,217	1.1	116.3	5,400	0.6235
0	76	1 163	4 168	0 191	0 117	0 98	1 65	3 175	22 2,239	1.2	117.5	5,450	0.6293
0	76	0 163	1 169	0 191	1 118	0 98	1 66	3 178	14 2,253	0.7	118.2	5,500	0.6351
3	79	0 163	0 169	3 194	3 121	0 98	0 66	1 179	18 2,271	0.9	119.1	5,550	0.6409
1	80	1 164	1 170	1 195	0 121	0 98	1 67	1 180	18 2,289	0.9	120.0	5,600	0.6466
0	80	3 167	2 172	1 196	0 121	0 98	0 67	3 183	24 2,313	1.3	121.3	5,650	0.6524
1	81	0 167	3 175	1 197	1 122	1 99	0 67	1 184	20 2,333	1.1	122.4	5,700	0.6582
1	82	1 168	2 177	0 197	0 122	0 99	1 68	0 184	14 2,347	0.7	123.1	5,750	0.6640
1	83	3 171	2 179	1 198	3 125	0 99	1 69	0 184	20 2,367	1.1	124.2	5,800	0.6697
1	84	0 171	1 180	1 199	1 126	0 99	2 71	3 187	20 2,387	1.1	125.3	5,850	0.6755
2	86	3 174	0 180	1 200	1 127	0 99	0 71	0 187	14 2,401	0.7	126.0	5,900	0.6813
1	87	5 179	2 182	1 201	2 129	1 100	1 72	1 188	29 2,430	1.5	127.5	5,950	0.6871
0	87	2 181	2 184	2 203	1 130	0 100	1 73	0 188	19 2,449	1.0	128.5	6,000	0.6928
3	90	1 182	1 185	3 206	3 133	0 100	2 75	1 189	25 2,474	1.3	129.8	6,050	0.6986
1	91	1 183	2 187	0 206	3 136	0 100	0 75	1 190	19 2,493	1.0	130.8	6,100	0.7044
3	94	1 184	0 187	1 207	1 137	2 102	3 78	0 190	21 2,514	1.1	131.9	6,150	0.7102
2	96	0 184	1 188	3 210	3 140	1 103	0 78	2 192	22 2,536	1.2	133.1	6,200	0.7159
2	98	1 185	2 190	2 212	1 141	0 103	1 79	2 194	25 2,561	1.3	134.4	6,250	0.7217
1	99	2 187	1 191	3 215	1 142	0 103	1 80	2 196	23 2,584	1.2	135.6	6,300	0.7275
2	101	0 187	1 192	0 215	2 144	0 103	0 80	0 196	10 2,594	0.5	136.1	6,350	0.7333
4	105	1 188	0 192	1 216	2 146	0 103	1 81	0 196	21 2,615	1.1	137.2	6,400	0.7390
0	105	3 191	0 192	0 216	2 148	1 104	0 81	0 196	16 2,631	0.8	138.0	6,450	0.7448
1	106	3 194	4 196	0 216	2 150	1 105	2 83	1 197	30 2,661	1.6	139.6	6,500	0.7506
1	107	1 195	3 199	0 216	2 152	0 105	1 84	0 197	22 2,683	1.2	140.8	6,550	0.7564
4	111	0 195	1 200	0 216	3 155	0 105	2 86	1 198	28 2,711	1.5	142.3	6,600	0.7621
2	113	0 195	0 200	0 216	0 155	1 106	0 86	0 198	12 2,723	0.6	142.9	6,650	0.7679
0	113	2 197	1 201	0 216	0 155	0 106	1 87	0 198	18 2,741	0.9	143.8	6,700	0.7737
2	115	0 197	1 202	0 216	0 155	0 106	0 87	1 199	12 2,753	0.6	144.4	6,750	0.7795
0	115	0 197	0 202	0 216	2 157	0 106	0 87	0 199	15 2,768	0.8	145.2	6,800	0.7852
2	117	2 199	4 206	0 216	2 159	0 106	1 88	1 200	28 2,796	1.5	146.7	6,850	0.7910
0	117	1 200	1 207	0 216	2 161	0 106	1 89	0 200	10 2,806	0.5	147.2	6,900	0.7968
1	118	0 200	1 208	0 216	1 162	0 106	2 91	1 201	14 2,820	0.7	147.9	6,950	0.8026
2	120	2 202	0 208	1 217	0 162	0 106	1 92	1 202	18 2,838	0.9	148.8	7,000	0.8083
2	122	0 202	2 210	2 219	0 162	0 106	1 93	0 202	22 2,860	1.2	150.0	7,050	0.8141
1	123	1 203	0 210	1 220	4 166	0 106	0 93	2 204	21 2,881	1.1	151.1	7,100	0.8199
1	124	0 203	1 211	0 220	1 167	0 106	0 93	1 205	12 2,893	0.6	151.7	7,150	0.8257
0	124	1 204	1 212	1 221	1 168	0 106	3 96	1 206	21 2,914	1.1	152.8	7,200	0.8314
0	124	2 206	1 213	2 223	0 168	1 107	1 97	2 208	24 2,938	1.3	154.1	7,250	0.8372
0	124	1 207	0 213	0 223	1 169	0 107	0 97	1 209	19 2,957	1.0	155.1	7,300	0.8430
1	125	1 208	1 214	0 223	1 170	0 107	0 97	0 209	15 2,972	0.8	155.9	7,350	0.8488
1	126	1 209	3 217	0 223	1 171	0 107	0 97	0 209	21 2,993	1.1	157.0	7,400	0.8545
0	126	0 209	0 217	1 224	0 171	0 107	0 97	1 210	10 3,003	0.5	157.5	7,450	0.8603
2	128	0 209	0 217	1 225	0 171	1 108	2 99	1 211	23 3,026	1.2	158.7	7,500	0.8661
2	130	1 210	2 219	1 226	0 171	2 110	2 101	0 211	24 3,050	1.3	160.0	7,550	0.8719
0	130	1 211	1 220	2 228	1 172	0 110	2 103	0 211	18 3,068	0.9	160.9	7,600	0.8776
2	132	2 213	1 221	1 229	1 173	1 111	5 108	1 212	14 3,092	1.3	162.2	7,650	0.8834
0	132	0 213	1 222	0 229	3 176	0 111	2 110	2 214	20 3,112	1.1	163.3	7,700	0.8892
2	134	2 215	0 222	3 232	3 179	0 111	1 111	1 215	25 3,137	1.3	164.6	7,750	0.8950
1	135	1 216	2 224	2 234	1 180	0 111	2 113	2 217	19 3,156	1.0	165.6	7,800	0.9007
2	137	1 217	1 225	4 238	1 181	1 112	1 114	1 218	23 3,179	1.2	166.8	7,850	0.9065
0	137	1 218	0 225	0 238	2 183	0 112	0 114	2 220	17 3,196	0.9	167.7	7,900	0.9123
3	140	0 218	0 225	0 238	0 183	1 113	0 114	0 220	6 3,202	0.3	168.0	7,950	0.9181
1	141	0 218	1 226	0 238	0 183	0 113	3 117	1 221	15 3,217	0.8	168.8	8,000	0.9238

TABLE XVI.

CONNECTICUT RIVER, HOLYOKE, MASS.

Nineteen Years, 1881 to 1899 Inclusive. Drainage Area, 8,660 Square Miles.

A. Cubic feet per second per square mile for twenty-four hours, that wheels, etc., are designed for.

B. Cubic feet per second per square mile, twenty-four hours' flow in ten hours.

C. Horse-power per foot fall per square mile corresponding with A (80 per cent. efficiency).

D. Horse-power per foot fall per square mile corresponding with B (80 per cent. efficiency).

E. Average number of days yearly on which flows A and B and powers C and D occurred.

F. Average number of days yearly on which flows less than A and B and powers less than C and D occurred.

G. Average flow for twenty-four hours on the days when flow was less than A.

H. Average flow using twenty-four hours' flow in ten hours on the days when flow was less than A.

I. Average horse-power per foot fall for twenty-four hours on the days when flow was less than A.

J. Average horse-power per foot fall using twenty-four hours' flow in ten hours on the days when flow was less than A.

K. Average available flow of full year, twenty-four hours per day with development A.

L. Average available flow of full year, twenty-four hours per day, with development B.

M. Average available power of full year, twenty-four hours per day, with development A.

N. Average available power of full year using twenty-four hours in ten hours with development B.

O. Percentage that available flow and power bear to the development A, B, C, and D.

C. F. P. S. P. S. M.	24 Hrs. A	H. P. per Foot Mile.		Full. E	Short F	Average Flow Short Days.		Average Power Short Days.		Average Flow Available.		Average Power Available.		Per Cent. Avail- able.	P
		24 Hrs. C	24 in 10 D			24 Hrs. G	24 in 10. H	24 Hrs. J	24 in 10. K	24 Hrs. L	24 in 10. M	24 Hrs. N	24 in 10. O		
0.2	.48	.018	.043	311	1	.19	.46	.018	.042	.20	.48	.018	.044	100	
0.3	.72	.027	.065	301	11	.26	.62	.024	.057	.29	.70	.026	.064	98	
0.4	.96	.036	.087	260	52	.33	.79	.030	.072	.39	.94	.035	.085	97	
0.5	1.20	.046	.109	227	85	.38	.91	.034	.083	.47	1.13	.043	.103	94	
0.6	1.44	.055	.131	201	111	.42	1.01	.038	.092	.54	1.30	.049	.117	90	
0.7	1.68	.064	.153	181	131	.46	1.10	.042	.100	.60	1.44	.055	.131	86	
0.8	1.92	.073	.175	164	148	.49	1.18	.045	.107	.65	1.56	.059	.142	81	
0.9	2.16	.082	.197	146	166	.53	1.27	.048	.115	.70	1.68	.064	.153	78	
1.0	2.40	.091	.218	133	179	.56	1.34	.051	.122	.75	1.80	.068	.164	75	
1.1	2.64	.100	.240	121	191	.59	1.42	.054	.129	.79	1.90	.072	.173	72	
1.2	2.88	.109	.262	110	202	.62	1.49	.056	.135	.82	1.97	.075	.179	68	
1.3	3.12	.118	.284	102	210	.65	1.56	.059	.142	.86	2.06	.078	.187	66	
1.4	3.36	.127	.306	93	219	.68	1.63	.062	.148	.89	2.14	.081	.194	64	
1.5	3.60	.136	.327	85	227	.70	1.68	.064	.153	.92	2.21	.084	.201	61	
1.6	3.84	.146	.349	77	235	.73	1.75	.066	.159	.94	2.26	.086	.205	59	
1.7	4.08	.155	.371	71	241	.76	1.82	.069	.165	.97	2.33	.088	.213	57	

Formulated by Chandler & Palmer, Norwich, Conn., from data furnished by A. E. Skuman, hydraulic engineer, Holyoke, Mass.

TABLE XVII.

FLOW OF STREAMS.

CONNECTICUT RIVER at Holyoke. Calculations made daily.

SUDBURY RIVER, near Boston. Calculations made monthly.

CROTON RIVER near New York. Calculations made monthly.

Cubic Feet per Sec. per Sq. Mile	CONNECTICUT. 19 Years. 1881 to 1899. 8,660 Square Miles.		SUDBURY. 19 Years. 1881 to 1899. 75 Square Miles.		CROTON. 19 Years. 1881 to 1899. 338.8 Square Miles.	
	Full Days	Per cent available	Full Days	Per cent available	Full Days	Per cent available
.1	312	100	304	99	312	100
.2	311	100	275	96	312	100
.3	301	98	258	92	312	100
.4	260	97	234	89	304	100
.5	227	94	218	86	281	98
.6	201	90	208	83	270	96
.7	181	86	190	80	256	95
.8	164	81	186	78	229	93
.9	146	78	180	75	215	90
1.0	133	75	170	73	195	87
1.1	121	72	162	71	177	85
1.2	110	68	158	70	169	83
1.3	102	66	152	69	160	80
1.4	93	64	145	67	148	78
1.5	85	61	137	65	138	76
1.6	77	59	127	64	134	74
1.7	71	57	122	63	126	72

The above "full days" were obtained by dividing the total number of days each flow occurred during the whole term of years by the number of years to obtain the average number of days each flow was available.

The percentage was obtained by adding the products of all flows by the number of days they occurred and dividing the sum by the products of the given development multiplied by the whole number of working days in the year.

Computed by Chandler & Palmer, 161 Main Street, Norwich, Conn.

DISCUSSION—STREAM FLOW DATA.

MR. HART: There was one point, Mr. President, that I did not quite understand, and that is whether these records are taken on the six-day week basis? Did I understand that that applies to that form of information or is a seven-day week given also? I simply wish to say this because, for an ordinary manufacturing plant the six-day week is the usual basis on which the information should be considered, but for a lighting plant or a plant that has to run more than six days per week, here in Connecticut we would have to consider it upon a seven-day basis. And it is particularly important here because of the fact that in a great many instances on Sunday the manufacturer gets the benefit of the pondage flow and in figuring the availability of a water supply, especially where there is no close figuring to be done, that has to be taken into account. The manufacturer who works but six days a week can draw upon the pondage, but a plant that has to run on Sunday may make a very serious inroad into the supply and may show that it is inadequate. This is especially the case with a power plant that has to run seven days a week.

MR. CHANDLER (by letter): In answer to Mr. Hart's question I would say that the Croton, Sudbury and Nashua calculations are made monthly and thus must include Sundays as well as week days. The Merrimac calculations are made weekly and include the Sunday flow. The Holyoke records give week day flows only. The Sunday flows, when there is considerable water running to waste, do not vary materially from the adjacent week day flows. At low stages of the stream the Sunday flow is only what leaks through the dam and such water as is used by any mills that run Sunday. That is, at Holyoke the Sunday flow signifies nothing regarding the natural flow of the stream, and while it has its place in weekly calculations or in daily data given chronologically, it would be misleading in daily data arranged in order of magnitude, as it would indicate a nominal flow only on many days.

METERS AND WATER CONSUMPTION OF THE HARTFORD WATER WORKS.

By Ermon M. Peck, Mem. Conn. Soc. C. E.

When the big, new Tumble Down Brook Reservoir was completed in 1895, it was predicted confidently by many wiseacres that Hartford would not need another reservoir for many years to come. The population of the city at that time was about 66,500.

In December, 1899, only a little more than four years later, however, with a population of about 80,000, or only about 13,500 greater, the city suddenly found itself confronted by one of the worst water famines in its history. To produce this condition of affairs, two factors were dominant, viz: unfavorable occurrence of rainfall and consumption greatly in excess of its needs. In this exigency the hustle gong was sounded for the construction department, and in record-breaking time, pumps, boilers, intake, and a new force main were installed, only to "die a bornin"; for, with all the irony of fate, on the very day upon which the new plant was to be tested, Jupiter Pluvius deluged the earth, and Hartford's latest water famine passed into history. In the meantime, however, for several weeks the decrepit old pumping plant which had been used to supply the city from the Connecticut River nearly half a century before, had been started into action, and limped along until one morning, crystallized from many years of over-straining, the piston rod of its engine broke, and the fortune of the Hartford Water Department looked darker than ever. The Hartford Street Railway Company was our good angel in this dilemma, and its general manager very kindly furnished and installed a motor to operate the pumps, so that in a few hours we were able to force filthy Connecticut River water into our mains with as much gusto as formerly, and continued to do so until the occurrence of the storm noted above.

field, 3,000. Floating population, equivalent to 4,000 regular consumers. The estimate of the floating population was arrived at by stationing observers at the outskirts of the city on the various trolley lines to count the passengers bound cityward.

Similarly, observers were placed at the Union Railroad Station. Each "floater" was estimated equal to one-third the regular consumer.

At the present time the department has 10,922 services and 10,814 meters, 99 per cent. of the taps being metered. This is a high percentage compared with that of other cities.

It should be said in this connection that the above reduction in the consumption of water has not been accomplished by meters alone, but partially by a rigid waste and leak inspection which has gone hand in hand with it. Inside the premises the inspection has been prosecuted by the meter readers. In the streets the water mains, services, hydrants, etc., have been inspected regularly by parties of men who did nothing else. The early experiences of this leak survey party were marked by the discovery of many leaks—some large and of long standing. The leak survey was established in 1902, but did not operate extensively until 1904. The large drop in consumption for that year I consider largely due to its work.

The rise in consumption in 1902 I consider due to the fact that the "big bill bogey," always easily conjured by the excited mind of the water taker, had failed to materialize and the reaction towards increased consumption usually noted in such cases had set in. This, of course, was cut down in the succeeding years by fighting waste and leaks.

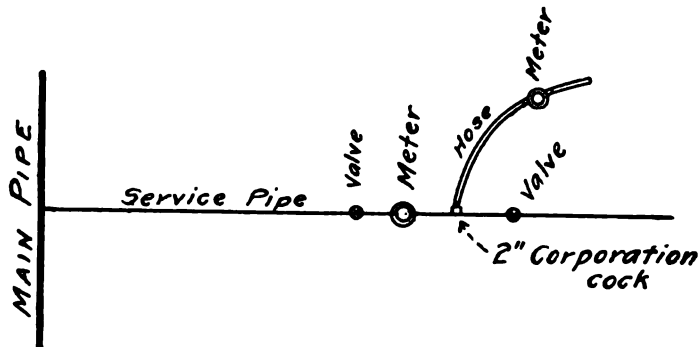
In this connection I may say that a very interesting computation was made during the past year designed to show the proportion of the water passing the Venturi meter at the distributing reservoir which could be accounted for. After making proper allowances for unmetered water, and under-registration of meters, it was found that only 16 per cent. of the water as registered by the Venturi remained unaccounted for. Since that time several of our fire service pipes have been metered, with the result that this percentage could be somewhat reduced.

Recently the Board of Water Commissioners has become impressed with the importance of systematic tests in order to keep the meters within permissible limits of registration. We

require all meters to test not lower than 98 per cent. and not more than 100 per cent. on full flow.

All five-eighth inch, three-quarter inch, and one inch meters are required to register on a one-thirty-second inch stream under the pressure at our testing bench, which would be equivalent to a flow of .0230 cubic feet per minute. It is the intention to test all meters at least once in four years and perhaps oftener.

Meters larger than one inch are required to test more in accordance with the service for which they are used than by a fixed rule, although as a general proposition one and one-half inch and two inch meters are required to register on a one-sixteenth inch stream equal to a flow of about .113 cubic feet per minute, the other requirements being the same as for smaller meters. The larger part of the meters above two inches in size are being fitted out to be tested in place. This is done by putting in a valve in front of the meter with a hose connection between the two. To test the meters the valve on the service is closed, the hose being connected up with an accurate meter in series with the one to be tested, as in the following sketch:



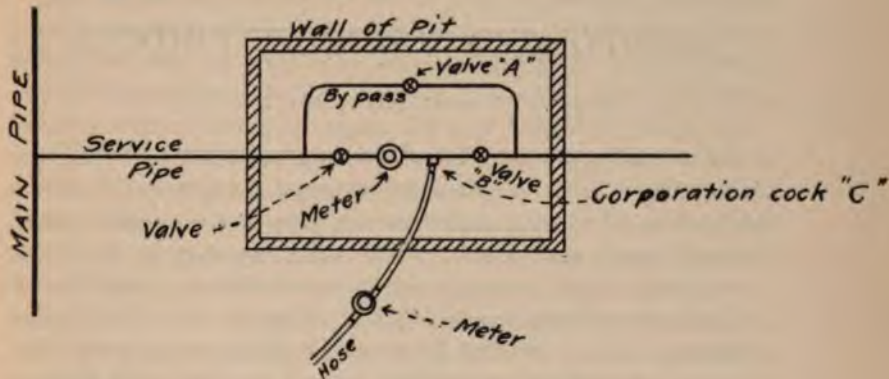
In laying new services the following plan has been adopted: A is a valve on a by-pass around meter. This valve is closed and locked at all times excepting when meter is being tested.

B is a valve in front of meter and C is a corporation cock for connecting up hose with accurate meter. To test meter, hose is connected up, as in the sketch above.

Valve A is then opened and valve B is closed.

The whole arrangement of valves and by-pass is placed in a concrete pit. By this method large meters can be tested with-

out shutting off the supply from the consumer, which is often a great consideration. The following sketch shows the arrangement of piping for this testing work;



Although this method of testing large meters has been in use for some time in other cities it has not been employed in Hartford any more than experimentally to ascertain its practicability. A party of men has been at work for some time during the present winter fitting up the larger services for these tests. It is our intention to test all the meters so arranged at least once each year and in some cases twice.

The meter card which has been lately designed for the Hartford Water Board, and which will shortly be put in use, is a large one, being approximately nine by fourteen inches. It is ruled and printed on both sides, one side being devoted to information regarding installation and the other to maintenance. An eighteen inch Elliott-Fisher billing machine is used for writing up the cards.

The writer may add that the card system has been adopted recently for the meter readers' books, and these, too, are written up on this machine.

REINFORCED CONCRETE BRIDGES.

By M. W. Denman, Mem. Conn. Soc. C. E.

Let me say at the outset that only my enthusiasm for my subject could fortify me with the courage necessary to address this society, of whose members so many surpass me both in training and experience. But if the little I know may be of service to anyone or if my own experience may lead to a greater knowledge of the subject and to a more extended use of this class of bridges, I shall feel that I have accomplished some good.

I do not think that I exaggerate when I say that to the railroad or city engineer no part of his work causes greater worry and anxiety than his bridges. All other parts of the street or line may be brought to the point where the cost of maintenance is almost an exactly known quantity; but if he has bridges of steel or wood, he must use "x" for the cost of maintenance, or else simply guess at it. So great is the desire to avoid all bridges possible that I think most engineers would recommend a channel change, wherever practicable, even though such a change might cost from two to three times the first cost of a bridge.

There are, however, innumerable locations in which bridges of some sort must be perpetually maintained, and my preamble has been only to emphasize the necessity of constructing the best bridge possible in such sites. If a bridge can be built for a reasonable cost and one can feel assured that the first cost will be practically the last cost, and that no danger of ordinary flood, fire or deterioration could menace it, then, as one prominent engineer expressed it, "one might sleep nights."

I firmly believe that, with proper study of the site, careful design and conscientious construction, no cause for troubled slumbers will be found in bridges of reinforced concrete.

I have been told by some engineers that they did not care to build reinforced concrete bridges because "it is a new thing and has not been tested and that someone else could do the

experimenting." To my mind such are as "they who, having ears hear not, and having eyes see not." Certainly they have not read their engineering papers, or kept in touch with the world at large.

Without attempting to review the history of reinforced concrete, I think it worth while stating that it has been under observation and test for over fifty years, and that its use in bridge construction considerably antedates that of steel. The first reinforced concrete bridge of which we have record in this country was built in the environs of Philadelphia in 1883; and while I have never seen it, I have been told that it is in practically as good condition to-day as when built. It was not until seven years after that date that either the city of Philadelphia or the Pennsylvania Railroad used steel in bridge construction; and the first record I have seen of such use was about 1885-6, when steel was first used in tension members in bridges built, for the balance, of wrought iron. In Philadelphia, where concrete construction has been given more attention, perhaps, than in any other city, several steel bridges, built since the date of construction of the bridge first mentioned, have been taken out and replaced with others of concrete.

The first bridge built west of the Mississippi was, I believe, that put up in Golden Gate Park in San Francisco by E. L. Ransome, in 1889. It is especially interesting, as it passed through the recent earthquake without a crack, which could not be said for stone bridges in the immediate vicinity.

As a matter of fact and record, I believe that of all forms of construction, none has a record of so few failures as the reinforced concrete bridge. Just how many have been built in this country cannot be stated, but we know, for example, that the Concrete Steel Engineering Company of New York has designed two hundred and fifty bridges, which are giving good service; the National Bridge Company of Indianapolis upward of one thousand, while individual engineers and railroads have built at least as many more. I think we would be very conservative if we say that at least three thousand have been built, and of them all how many failures have occurred? I have never heard of but three, and they may be considered in some respects as giving additional proof of the value of this form of construction; for in each case the failure occurred when the centers were removed, or when the first test load was placed upon them. If

properly designed, it is almost impossible to so illtreat the material in construction that, upon removal of the forms and centering, the bridge may look all right and yet be defective. Then, too, another feature in favor of it is its increasing strength as time goes on. Steel and wood grow weaker with age, while concrete is the only known construction material which grows stronger as it grows older.

Like everything else, reinforced concrete is better adapted for some forms of construction than for others, and among the most suitable is that of the arch. Concrete is very strong in compression and very weak in tension, and it naturally follows that the arch being more in compression than any other form, concrete should be used for compression strength, with steel added to provide against tension.

It is with considerable hesitancy that I approach the question of the kind of reinforcement to be used. An old adage says that "In a multitude of counsel lies wisdom," but the engineer who makes a study of the multitudinous methods of concrete reinforcement is apt to cry "This way lies madness."

As I do not wish to appear to advertise any special system, perhaps the sanest thing I could say would be to advise solely that such reinforcement as is used should be the simplest possible to do the work—and stop there, and in what I shall say, please consider me as a constructing, not a designing, engineer. There are a number of patented systems, all of which have some virtues, although with many the faults more than counterbalance the virtues. I am firmly convinced, however, that the average engineer, who has the construction of a concrete bridge placed in his hands, will be wise if he will turn over the designing to the specialist, rather than to attempt it himself. While he could, doubtless, design a bridge which would be safe, the chances are that, in his desire to be absolutely safe, he will burden the structure with from twenty-five to one hundred per cent. more material than the load requires, and he will not get all of it where it will do the most good.

I recently talked to one engineer in a large Eastern city, who said to me, "Why, I couldn't let another man design an arch bridge to be let from this office. What do you think the people pay me for, anyhow?"

"How many arch bridges have you designed?" I asked.

"Only one; but I could design as many as I wanted to."

"Doubtless you could, I replied. "And doubtless the people would pay you and pay for the bridge; but I cannot agree that they are paying you just to do the mechanical work for them. My conception of your position is that you are there to get for them the fullest value and surest results for their money. If you had trouble with your eyes, would you go to your family physician, or to an oculist?"

Well, he got hot and I gave up the task.

Gentlemen, this is a day of specialization in all professions and engineers should be as willing to consult those who have had greater experience in certain lines as the general practitioner in medicine is to call in the services of a specialist. Some of you may reply that mathematics is an exact science, while medicine is not. To that I should say that if the President of this Society of Engineers were to hand to each member a profile and description of a bridge site and should ask that each one should design a bridge to fit that particular site, the designs would be as various as the number of members and—perhaps some of them might fit.

So I will repeat that I believe that the man who makes a specialty of any particular method of reinforcement and has obtained tested results which may be depended upon, is the man who will give you the safest bridge at the least outlay, as a rule.

Yet there are certain features of reinforcement which I think it well to avoid. First, I do not believe that, in the construction of an arch, it is as well to lap tension rods as to have them really continuous. If rods are purchased in stock sizes, it costs very little to weld the extrados and intrados rods from abutment to abutment. Or, if sufficient time can be allowed, these rods may be obtained from the mills in full lengths. When this is done, it is not necessary to have extremely long rods shipped on two or more cars, but the rods may be bent into thirty-foot lengths and placed on one car. Upon receipt they may be heated enough to straighten, which costs much less than welding.

Second, I think that all steel which is not used for either compression, tension, or shear, should be eliminated. That may sound like stating a self-evident truth, but I have seen arches within a thousand miles of here which had so much reinforce-

ment that there was hardly room left for the concrete. There were scores of members shooting up from the lower rods and down from the upper rods, all of which, except about three, taking up space which could have been better filled by a much more useful and cheaper material—concrete.

I find that a great many engineers have the mistaken idea that such a reinforcement “bonds the concrete together.” I think that with clean gravel, good cement and mixing, and plenty of manpower on the tamping, the concrete will bond itself without the use of octopus-like tentacles running hither and thither without rhyme or reason. Then, too, these useless members are worse than useless in that they greatly interfere with proper placing and tamping of the concrete.

I am often asked which of the many deformed bars I prefer, and to that I reply that, for the most part, you can pay your money and take your choice, for there is little advantage in one over another, except to the manufacturer. In an arch, I think there is little use for anything but a plain rod, with no excrescences, hollows, holes or other “talking points.” While I do not maintain that the adhesion of concrete to the smooth rod is always as great as the adhesion to a roughened bar, I do think that it is sufficient for an arch and, in many cases, for the girder; but whatever form is adopted, my preference will always be for one made of mild steel which may be welded to full lengths in the manner I have mentioned.

When we come to the actual construction of the bridge there is very little difference of opinion among those having experience. Most engineers agree that good, clean gravel will make a denser and better concrete than broken stone and, when found near the bridge site, lessens the cost very materially. A proportion of one part cement, three of sand and six of stone is generally used for footings and mass masonry, and the proportions of 1—2—5 for the arch ring. If the bridge is designed on a basis of three hundred and fifty pounds to the inch compression strength for the concrete, gravel which runs in approximately the above proportion may be used just as it comes from the bed and without screening; but if five hundred pounds or greater to the inch is used, it then becomes necessary to be much more careful in grading the materials. It is, of course, most essential that the abutments should rest on solid material, or, failing such material,

that enough piles be driven to obtain the same result. The abutments are then run to the springing line and left with a skew-back to receive the arch ring.

That done, the next thing—and it is one of the most important items in the construction of the concrete arch—is the building of the centers. I find that, in the East, most arches are built like a stone arch, with perfectly rigid centers, which are left in until the load has been placed on the span and the concrete has become thoroughly set; usually from four to six weeks. In a few cases, wedges are used, but without much method and without obtaining even and regular results.

In considering the centers to be used, several objects are to be borne in mind. First, that we must have a form which will be rigid during the placing of the arch ring. Second, a form that will not be excessive in cost, and third, a form which will permit of the settlement and shrinkage of concrete which will occur after the arch ring is run.

Just the proportion of shrinkage which occurs is, up to date, an unsettled question. It seems certain that if we take a volume of dry materials like gravel and cement, add a quantity of water to it, then put it into molds and permit it to dry out, the evaporation of the water will reduce the volume to some extent. Not, however, to the extent of the volume of water we have added, for some has combined, chemically, with the cement and will always stay there. There will be, however, some settlement due to this shrinkage, even though it be very slight. There will also be some compression of the mass in the foundation after the arch ring and spandrel walls have been put up, while the load of the earth fill will be later carried down the arch ring to set up a still greater compression of the abutments.

Now, if the centering has been put in rigidly, it will usually be found that, after its removal—even though sometimes it be many months later—cracks will be found in the spandrels and rail, which have been occasioned by the later settling of the abutments and ring. As this settlement varies in proportion as the height of the abutments, the weight of the load, the length and rise of the span, it would be almost impossible to so proportion any wedge system which would take care of it. For example, the Big Muddy bridge, built by the Illinois Central, with a span of one hundred and forty feet, settled over three inches, while in

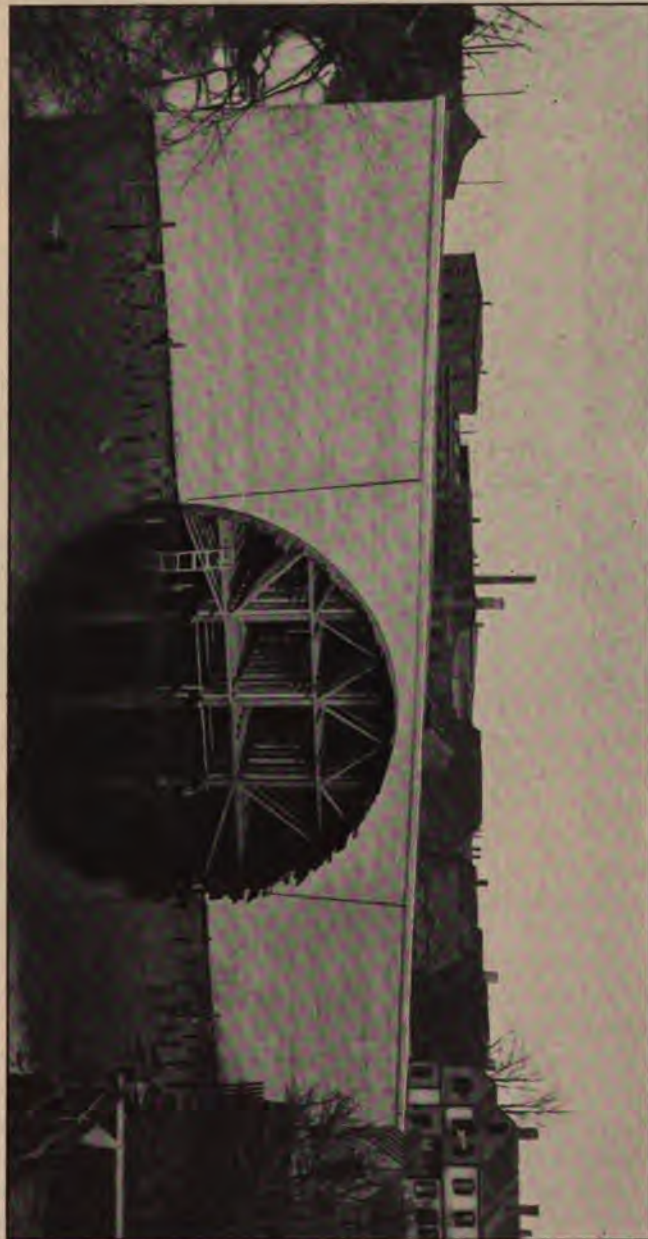
other cases little or no settlement was noted. Now the method we use in centering takes care of all this in a very easy and simple way.

We use bents of vertical posts which are, in themselves and unbraced, just a trifle too light to carry the load which will be imposed upon them, but which, when fully braced in both directions, will be perfectly rigid during construction. Usually, these posts are made up of two pieces in the form of a "T," but are wired, not nailed together.

The sheathing over the drum of the arch is made of dressed lumber and made as smooth as possible, although for the average bridge over a waterway, I do not think it worth while to attempt too great a nicety here, as it never shows and strength alone is more to be considered than appearance. It is only essential for such openings that we get it tight enough to prevent undue leaking at the joints.

The arch rings we usually run in sections of from twelve feet and upwards in width, taking such a yardage as we are sure we can run in one day. While that is being placed, the carpenters are building the forms for the spandrel walls, and here the greatest care must be used to obtain sightly results. We have found that forms made of two-inch lumber, not tongued and grooved, but surfaced on three sides, carefully placed, will give us the smoothest wall. Usually we wet the forms until they are non-absorbent and depend upon thorough spading to produce the smooth surface. At Plymouth, Mass., we built a bridge with walls at each end thirty-six feet in length and from twenty-four to thirty feet in height. The forms for these walls were made of seven-eighths inch tongued and grooved lumber with studding placed closer than usual. These forms we wet lightly with kerosene, spaded the material thoroughly, and the resulting wall is one of the smoothest I ever saw.

To get the best results, we much prefer that, before building the wing-walls or hand rail, that the earth fill be put on and the centers struck. I do not mean by this their removal, but by the time the fill can be made the arch ring will carry itself, and is putting nearly all the load on the haunches and abutments which is possible. At that time, then, we take off most of the bracing and cut the wires on the "T" verticals, permitting them to buckle under the load, and the arch to assume its final position.



REINFORCED CONCRETE BRIDGE, MAIN STREET EXTENSION, PLYMOUTH, MASS.
ROADWAY 50 FEET, SPAN 40 FEET. VIEW DURING CONSTRUCTION.

Then we run in the wing-walls, usually with an expansion joint where it meets the spandrel, and add the rail. Where this method is consistently carried out, we have never had a case of cracked spandrel or hand rail.

The artistic treatment of a concrete bridge is solely a matter of personal taste and the size of the pocketbook. Built in its simplest and most severe lines, the arch always makes a handsome and artistic structure, while as much adornment may be added as one desires. Being a plastic material, concrete may be molded into almost any desired form, and the spandrel walls may be bush-hammered or picked, and a very attractive surface so obtained.

For the rail, I consider it advisable to choose one which may be built monolithic with the spandrels and properly reinforced. While a molded rail may carry much more gingerbread and may be more ornate, yet it is difficult to so construct such a rail that some of the balusters will never become loose or some such defects occur. If built in place, the rail may be made quite pretty in a great number and variety of forms, and its solidity and longevity are worth more than complicated forms which must sooner or later, be repaired.

Neither do I think it ever advisable to place steel hand rails on a concrete bridge. The hand rail is usually the first part of a steel bridge which rusts out and must be renewed; why, then, in the construction of a bridge which we believe to be permanent and everlasting, should we add a part which will require continual renewal? More often than not, the rail would not be kept properly painted and, consequently, the steel would rust and the rust soon stains the spandrel wall beneath. The cost of a steel rail is so nearly that of the concrete rail that even for the matter of first cost it is not economical and, with the objections to which I have referred, should never be used unless unavoidable.

In short spans where full head-room is desired for the full width of the opening, girders of reinforced concrete are both economical and satisfactory, although they will rarely be found advisable to use for greater spans than sixty feet. Up to that length, the cost will compare favorably with that of steel construction and the maintenance features are as favorable in the case of the girder as of the arch. When built monolithic

with the abutment walls and continuous reinforcement properly placed, the whole bridge may be designed for a very low cost. The abutment walls in such a case may be made very thin, as there is no overturning force, and it may be considered as a beam supported at each end. The girder is much easier of design than the arch and the placing of the steel to provide against tension a matter of little difficulty.



REINFORCED CONCRETE BRIDGE, TOWN OF COVENTRY, R. I.
ROADWAY 16 FEET, SPAN 75 FEET.

In conclusion, let me repeat that I fully realize that I am overstepping the bounds of modesty in attempting to discuss this question before you, but the *Engineering News* some time since made a remark which may possibly apply to me. Certainly, I think of it each time I undertake the construction of a bridge. It was in reporting the reasons for the failure of some reinforced concrete building and the editor of the *News* had patiently repeated that this failure was not caused because concrete was used, but because neither the man who designed it nor the man who built it had ever had any previous experience with the material; and he wound up by quoting that trite but true adage that "Fools will rush in where angels fear to tread."

DISCUSSION—REINFORCED CONCRETE BRIDGES.

MR. HILL: Mr. President, I have been very much interested in the paper which Mr. Denman has read. I think his suggestions are most admirable, but we have so much to do to-day, that I hardly think it is worth while to take much time for a discussion. The points in designing which he refers to are very important, and I think there is no question but that a concrete bridge has to be very carefully built. I think all engineers are in accord as to that.

MR. KELLY: There is not much that I can say. There was one point, however, that the speaker referred to in the matter of forms. We had a little experience in using two-inch plank, which may be of some service to the others. We found the difficulty with the kind of lumber that the contractor furnished to be that it was very difficult to get a tight joint with it. Of course it is necessary to have a tight joint and it was impossible to secure it, as the plank could not be sprung in the direction of the width of the plank. After that we began to use $\frac{7}{8}$ -inch plank, tongue grooved, and by the use of that we got a perfectly tight joint.

MR. HARTE: Mr. President, in the matter of forms for concrete work, very often attention can be paid with considerable benefit to the designing of the forms in sections so that the units can be used repeatedly. This type of form is particularly adapted to continuous retaining walls, but can be used advantageously in many other situations. In the Port Morris depression of the New York Central Railroad in the city of New York, such a panel system was used with much economy, and a system based largely upon that has been employed in the New Haven cut work. The chief difficulty with the repeated use of the timber comes from misshapements, due to the absorption of moisture, but this can be prevented by allowing the forms to dry as soon as they are stripped, or after removing them from the work, and then treating them with a coat of raw oil.

Regarding reinforced concrete itself, the speaker cannot too strongly commend Mr. Denman's position in regard to the rational use of the reinforced material. If, as is believed by many engineers to-day, reinforced concrete is a construction material having a definite behavior under definite load conditions, it should be used as such. The speaker has no patience with

engineers who design with more or less care a reinforced concrete structure and then add sufficient concrete to practically make a gravity section for good luck or for good measure. The construction, in the speaker's mind, should either be reinforced concrete in which the behavior of the concrete and the steel is calculated and their proportions determined by these calculations, or it should be a gravity section in which all of the stresses are carried by the concrete. If the engineer has not sufficient confidence in his construction to build it as the formulas would indicate, he should, in my judgment, let reinforcing severely alone and stick to gravity sections.

MR. KELLY: I might offer one more remark. I think there is one point that should be emphasized, and that has not been noticed enough, perhaps, and more especially in connection with reinforced concrete, than in any other kind of construction, and that is the inspection. You may have your reinforcement put together ever so carefully and your design made ever so economically and carefully, but if the concrete is not properly put in, is not uniformly mixed, you are going to lose a large percentage of the benefit of the reinforcement. The observation of any one who is familiar with concrete knows that it can be very much abused, especially in the handling of the material. The inspector should be a man who is reasonably intelligent, and should watch closely every part of the work to see that it is properly done.

MR. DENMAN: If you will pardon me, Mr. President, I should like to give a little of my experience, which thoroughly convinced me of the necessity of putting on an inspector. To illustrate it, take the case of the bridge which we built at Plymouth, and to which I referred. The committee had only about so much money to spend and they had put out pretty nearly all of it in the construction of the bridge itself, so that when the suggestion was made to them that they had better put an inspector on, they said: "Well, we have only got about so much money and we can hardly afford to do it." I said, "I will tell you what I will do. If you will put on an inspector that you can depend on, one that will work and stay there, and see that the forms are properly put up, and that the concrete is properly mixed, I will pay the cost." That is the way a contractor has got to do, that is building a reinforced bridge; especially so if he is doing it on a contract, and has furnished

the design himself, he has got to back up the design. He cannot afford to take any chances. If he is solely dependent on his foreman he is very glad to have a competent inspector put on that job to see that the work is properly put through, and it is of the utmost importance that that inspector be put there and made to stay.

THE PRESIDENT: This discussion is very interesting. I think there are others here who would like to take part in it.

A MEMBER: Mr. President, just before Mr. Kelly rose, I was going to suggest practically the very same thing. Proper inspection of doing the work, whether done at the instance of the contractor or because of the necessity of having someone over the foreman of the work, is really much more than half the battle in attaining success. On the work of the inspector depends more than half of the success of the structure. A poor mixing of the material or poor placing of it, the tamping it improperly, all of these things are to be carefully watched, because if there is any serious mistake made, it detracts a great deal from the success of the job. In too many cases the inspector is left out, and a large proportion of the accidents that we hear of are due to the fact that there is not sufficient care taken in the building and inspection of the bridge as it is being put up.

MR. VERRILL: I would like to emphasize that too, Mr. President. I think a great many times the inspectors are not the right ones, and a good deal depends upon the selection of the right man. It is very well to put on somebody who may be an A-1 bricklayer, and who has a fairly good knowledge of concrete, but oftentimes we are apt to get someone who has ideas of his own which are not correct and who tries to follow them out. We have seen a great many cases of that and it leads to poor results. I remember a case where they were building a sea wall, where the wall ran down below low water, a very heavy wall at the base, but a wall which really needed no reinforcements whatever: the man who designed it had provided for putting in some horizontal sheets. They were poultry netting. They had an inspector there who was watching closely to see that these poultry nets were put in. They did absolutely no good, and while he was closely watching that part of the work too much water was being put in and washed all of the cement out. The inspector, while he was watching with the utmost care

to see that the sheets of poultry netting were gotten in all right, was not paying attention to the thing which was bound to lead to trouble.

THE PRESIDENT: Is there any one else who desires to discuss this question?

MR. BUCK: In regard to the merits of forms, and as to whether we should use smooth edged or tongued grooved ones—I did some work several years ago on some caisson work where we had quite a high bridge wall about twenty-three feet wide and about five hundred feet long. For the supports we used 6 x 6 verticals. The forms were not tongue grooved and we got better results without using the tongue grooved. After we got through, the transit was run right over the whole of it and it showed a variation of not over half inch one way or the other.

MR. DENMAN: I think the heavier material tends to keep the wall from bulging.

As a rule, by the use of two-inch stuff with a grooved surface, so it is even, it gives good results, but very often by cutting it so that where the two pieces match together, you can wedge it in that shape (indicating), you can make an absolutely tight joint. Even in that case the man who puts it up has got to be very careful in placing the forms. The way the contractor uses his forms is the part of it, as a rule, where the contractor makes or loses money, and the more economical forms he can use the cheaper he can make his bid for the work and the greater his chances for making some money at the end of the job. For that reason these vertical posts that we have used have given us excellent results, because all of these posts may be used over and over again. You can take them off and put them right back again in the same wall and there is no waste of lumber, or rather not so much waste. There is another benefit in using two-inch lumber that is not tongue grooved, and that is, when you come to take down the tongue grooved lumber it is almost invariably torn to pieces. If the people are taking it off a wall that is of any height, they have to get at it the best they can and pry it off, and, of course in doing that, they will break more or less of it. They cannot help it. I was talking, the other day, with a contractor from Pennsylvania who had put up about fifteen arches in the last year, and he had used in every case for forms, what he called "Bull pine." It was a very cheap material. It was

a tongue grooved lumber that he was able to throw away when he got through with it. Perhaps it will be even more advantageous to use lumber of that kind in that place, than to try to save the lumber.

THE PRESIDENT: I understand that in the handling of this class of work the question of shrinkage is an important one. If some member will give an expression of opinion on that point I think it will contribute to the value of the discussion. I think Mr. Sperry has had some experience with that work.

MR. A. W. SPERRY: This paper has opened up a wide field for discussion. There are so many sides to it that it is hard to discuss all of them at this time.

I was glad to hear Mr. Denman refer to the question of forms, materials, quality of concrete compared with ratio of steel to concrete, etc. I think it is quite well understood that this last item is an important one in the designing of concrete. I have had my own views, rather decided ones, about these questions for some time.

I think we should have courage enough to rely upon our figures after we have made them. I believe the work of our office has been criticised as being rather light, but we do not believe in adding a percentage for luck after we have compiled our figures. It comes down after all to the question of a man having confidence in his own figures, and not having to add for luck. I was glad to hear Mr. Denman bring out this point as he did in his paper.

The matter of forms from the contractor's standpoint is much the most important question in connection with concrete construction, because in building a structure you are really building two structures, first one of wood and later one of concrete.

The idea of letting down some of the centering supports for concrete arches seems to be a risky one, and would naturally require great judgment and care. Of course, it is hardly necessary in arches of small span, but in large ones I can see where it would be considered a risky procedure.

In regard to forms. In some cases, we have used them over and over again; in one case nine times. This being made possible by taking great care when they were first made and put up, making them so they could be removed without destroying them.

I had in my mind one other subject, the question of shrinkage. I think it is well understood that concrete will crack, if used in

walls and like structure and reinforcement is not used about every twenty feet.

We have an example of this here on Prospect street, where we built a concrete retaining wall. Reinforcing rods were used to prevent contraction, the rods being placed in the top coping. I think there was one cross section where the rods were omitted, due to the fact that they were hardly thought necessary in that portion, and the result was that we had a crack at about the twenty-foot mark. The question of shrinkage can largely be taken care of by having the proper amount of steel placed in the concrete.

MR. DENMAN: The particular amount of shrinkage in a wall, or the amount of settlement or shrinkage in the arch ring, is absolutely impossible to determine, and I think most all of us will agree about that. It has been very clearly illustrated in the



course of the Connecticut River bridge, at Hartford, and it is not due to any fault in the design of the bridge nor care in the construction. At Hartford, from the locality where these cracks appeared, the abutment must have settled at one end, as it could not have occurred very well in the solid work. The joints between the masonry must have compressed sufficiently under the full load for these cracks to open, which they did just back of the abutment at either end. There was also a crack appeared over in one end near the handrail. Although I have had a good deal of discussion with several engineers, we have not been able to decide just how that occurred, but that is something that is very apt to appear even in the most carefully designed structures.

Mr. Sperry referred to the question of its being a little risky to use vertical supports which appear to be a little too light, and which bend under the load. It would seem so on the face of it, yet in the construction of over a thousand bridges by the National Bridge Company they have used that system, and with never an accident due to that cause. As a matter of fact the arch ring, in

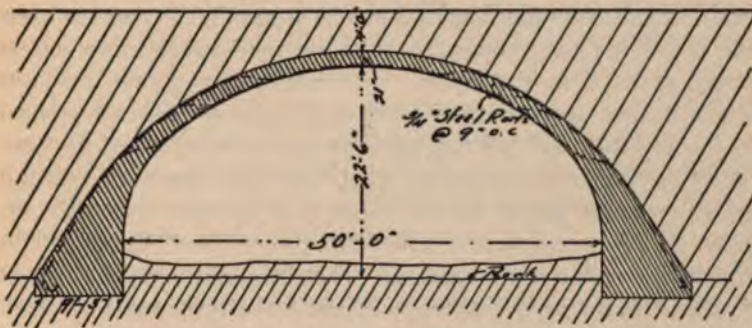
almost any weather, will sustain itself for three days. but it almost invariably proves too weak to sustain itself from the time it is first put up, but by the time you get ready to release these supports from the arch ring it is all right and these verticals can be released with perfect safety. The verticals are strong enough to carry the full load. The question of the time that the arch ring is taken off, or that it will sustain itself, received a curious shock, or at least it was to me, when building a three span bridge last year. The design called for two eighty and one seventy-foot spans, the seventy-foot span being at the lower end. The spans were balanced so that the two eighty-foot spans practically balanced each other. It was one of the most interesting things I have seen occur in a very long time and I do not know how to account for it. Beginning at this end we ran one thirteen-foot arch ring all the way through, and it took about three days to run that ring. Then we went back and brought up the other. The bridge stayed up all right and there seemed to be no trouble of any kind. When we took off the forms we started with this seventy-foot span and carried the work through that first thirteen-foot arch ring and we found it had raised up about a quarter of an inch before the second ring was put in at all. It showed that there was a little bit more pressure on the seventy-foot span against this one ring which had been run there, but it had resisted it and stayed perfectly satisfactory. In two days it was perfectly safe to cut the wires on the verticals and take off the braces, because that affected but a comparatively small load, and it was amply built to carry in a perfectly safe condition.

MR. KEITH: There was one matter which we slid over very lively in the paper and which it may be interesting to refer to. I hesitate somewhat to call attention to it lest it should divert the discussion, more perhaps than it is advisable at the present time. I will refer to it briefly. Mr. Denman, if I understood him aright, advocated the use of mild steel in the reinforced concrete. Now when it comes to a steel structure I am very emphatically in favor of the mild steel, but in reinforced concrete work the matter is entirely different. In reinforcing work the elastic limit is an important feature and the relation of that elastic limit to the compressive strength of the concrete is quite essential. It is not sufficient that there be enough strength in the material to carry the maximum strain upon it without yielding,

or without stretching so as to destroy the permanent set, and that set must not be disturbed to such an extent as to open the crack. For that reason I believe that a medium steel is far preferable to a mild steel.

As I said before, I hesitate to bring up this subject, but it seems to me that it is a very important one and in that particular class of construction which I have referred to, we should use the other class of steel rather than the mild.

MR. DENMAN: You are not going to get a fight out of me, I am sure, because I believe in the mild steel for such forms of construction myself. I do not believe in using the high carbon steel for the reasons that I have mentioned in the paper, and



for the special reason, in reinforced concrete work, that it is essential in a great many cases to bend the rods. There are one or two cases where I have been forced by engineers against my judgment to use the high carbon steel. I would take it and put in enough of it to do the work, but we have had an enormous amount of trouble in bending the high carbon rods and for that reason I was rather against medium steel. In fact, I am rather inclined to agree to use a mild steel altogether, except in such instances as this (speaker illustrates on blackboard). Now in putting in a possible reinforcement on a structure like that, the rods would have to be put in in this shape. That rod would have a hook there. When it comes up over, it has a short turn there, alternating in crossing the arch ring, and we have got to have a rod that we can bend there. Now in one case where I used the Johnson bar, I heated the rods and did it just as carefully as possible, but wasted at least ten per cent. of our steel in

using it. They say you can get a Johnson bar in medium steel. If that is so, it is a very decided improvement. In many forms of construction you are met with so many bends and kinks that the high carbon steel is practically out of the question, because in bending it, even under the most careful conditions and with the most careful treatment, you will lose some of the steel at least.

I was going to state that when you come to go into the question of design, you can perhaps entangle me, because I turn all of my designing over to specialists.

MR. SPERRY: I would like to ask Mr. Denman what his idea is of the consistency of concrete for bridge work?

MR. DENMAN: Why it should be nearly as wet as you can use it. I do not mean by that a sloppy mixture, but it should be of such a consistency that you can handle it readily. Over the arch ring it is practically impossible to use a very wet mixture. You cannot allow it to run much. For instance, you take an arch that will have approximately that rise (speaker illustrates from the blackboard) and in bringing it up here to that point, we have got to have a concrete that is fairly dry. In the spandrels the wetter you can get it in the better job you can make of the spandrel. A wet concrete will adhere very much better to the steel than one in a dry condition. That has been very thoroughly explained in the report which has been made upon some of these concrete steel chimneys which have been erected. One of the principal manufacturers got very good results, considering the amount of work which he puts out, from using a very dry mixture, but they found in a great many instances that the concrete had not adhered to the steel. A test was made, I believe, to determine which was the strongest, but it only showed a maximum of about one hundred and fifty pounds over the wet, it being something like 2,150 against 2,300, we will say, and that was in the most perfect condition, all making the cubit from which they made these tests. So I say, where it is possible, it is better to use it as wet as we can without throwing water in just for good luck. It will usually give better results.

MR. SPERRY: You mean without making it practically impossible to tamp it?

MR. DENMAN: You could be governed by circumstances as to the particular locality in the structure where it is to be used. It is practically necessary, as I show from this drawing, to use it

in a wetter condition up here than it is here; there is a difference which should be made between using it on the spandrel and when you go on to the arch ring. It seems to me it has got to be moist enough there to thoroughly tamp about the rods.

C. L. SLOCUM (by letter): Mr. Denman's paper on the economic and æsthetic advantages of reinforced concrete bridges is an interesting addition to the literature of this subject. While this construction is, perhaps, still in an experimental stage, it surely is showing some indications of maturity, and engineers can ill afford to pursue any other policy, except an aggressive one, in the use of this type of construction. The profession has been a long time used to looking at the large, cumbersome constructions in masonry, such as bulky retaining walls and huge arches of stone, aptly described as "veritable combinations of main strength and stupidity." Sensible of the wise conservatism and the great merit and usefulness of the gravity construction of the past, we now have, in this skeleton construction, the main strength, with the stupidity left out. Considering its age, reinforced concrete has at least as few failures to its credit as steel construction of a corresponding age.

Probably every independent specialist in this line of construction has pet methods and schemes, a product of his own study and investigation; still if his functions are purely engineering, and in no wise connected with those of contracting, his judgment on the relative merits of a piece of construction is less apt to be biased. The functions of contracting and engineering had better be entirely separate and distinct. There are numerous engineering and contracting companies, and many of them above criticism, who, if they can obtain the contract for a job, and supply their particular reinforcement, or use their patented method, will furnish the engineering free. The writer thinks it might be well and profitable to overhaul and scrutinize plans that are thrown in free. While it is not always necessary, or always done, it is a better rule to do it. In other words, independent investigation, representing a buyer, generally pays for itself.

It is certainly far better to have continuous reinforcement in arches, slabs, and beams, and if welding in the field was all that we would wish it to be, it would certainly be the ideal method. Generally speaking, a welded joint is not as good as the original section, and should not be permitted where the full section is

used. Proper facilities for perfect welding are too expensive, and splicing in concrete is the cheapest and safest expedient. The writer knows of no standard specifications recommending welding, and in fact in some it is expressly forbidden, probably on account of its uncertainties.

In fabricated reinforcement the numerous connecting links or lattice, making a stiff independent unit, or steel frame, perhaps cannot be theoretically justified, but it gives the reinforcement a positive character. The best engineers, of world-wide reputation, are partial to fabricated units in preference to reinforcement, non-supporting in itself. The extra rigidity amply justifies its use. The wide and extensive use of skeleton frames in the early days of reinforced arch construction, its undiminished use to the present day, rather vindicates its usefulness. The theory of the arch is one of great complexity, and we assume much in figuring one. The effects of shrinkage and changes in temperature are problematical and uncertain. The bond between the barrel of the arch and the spandrel walls above it vitiates the results of stress computations for changes of temperature. Many reinforced arches are built to-day which, according to theory, do not require any steel, but which is used as an extra measure to secure toughness and stiffness. In heavy railroad or trolley work, a conservative policy appeals rather strongly. If the writer understands Mr. Thacher aright in his classic papers on reinforced concrete arches, he endeavors to have the line of pressure lie within the middle third of the arch ring, and have no tension in the concrete from dead or live load. He says this can be done with a due amount of patience, not only as regards dead and live loads, but temperature stresses as well. The writer quite agrees with Mr. Thacher when he says that he "does not approve of paper-like dimensions, nor of designs which would not be reasonably safe with the steel left out, but in the vastly increased security which the steel affords in providing against shrinkage, settlement or other conditions which cannot be calculated, or foreseen with any degree of accuracy. The steel in this case acts as a powerful reserve force comparatively at rest so long as the concrete is able to do its share of the work, but ready to step in and do it all if necessary in case of emergency." The merits or economy of this construction are not destroyed by such conservatism.

Mr. Denman's methods in handling the centers of an arch are comparatively new, and a decided advance over earlier methods.

Balustrades or railings for reinforced concrete bridges should certainly be properly and fully reinforced, and built monolithic with the rest of the construction, as Mr. Denman says. The additional expense is trifling as compared with the greater security against the effects of shrinkage and temperature changes.

THE HARBOR AND RIVERS OF NEW HAVEN.

By J. Frederick Jackson, Mem. Conn. Soc. C. E.

Probably the first white people to come to New Haven were the seven men of Captain Eaton's party, who having chased a Pequot war party from Saybrook through Fairfield county spent the winter of 1637 here in a hut. They were followed the next spring by John Davenport, Theophilus Eaton and their party and the land was formally purchased from the Sachems, Momauguin and Montowese, of the Quinnipiac and Mattabesec tribes. Prior to that time there is no doubt that the harbor was known to the old Dutch navigators and shown on their charts.

The harbor according to T. Dwight's statistical account in 1811 "occupied an area of about six square miles and set up from Long Island Sound a distance of about four miles. It is 240 rods wide within the beach. The channel lays near the east side and has a depth of fifteen feet at low water from the Harbor Bridge, (now Tomlinson) except on a sand bar formed by the erection of an isolated pier about one mile from the head of Long Wharf, where the depth is but six feet at low water; a foot and a half has been added to the former depth since the construction of the bridge, and this benefit is still increasing. A common tide is six feet and a spring seven or eight."

The old maps—"A Plan of New Haven" by Joseph Brown in 1724, one by General Wadsworth in 1748, and "A plan of New Haven Harbor" by President Stiles in 1775—do not give us much information. They show the isolated pier above referred to, and the two creeks on either side of State and Meadow streets. The arm on the west side of Meadow Street was originally called the Winter Harbor, and about that same time vessels loaded and unloaded on the east side of Fleet Street.

The harbor is formed by the confluence of three rivers, the West River which rises in Woodbridge and is about ten miles long, the Mill River which rises in Hamden and is about the

same length, and Quinnipiac River (or long water place), sometimes called the Wallingford, which rises in Southington and is about thirty miles long. Here let me quote from the Manual of Geology of Connecticut:

"The Farmington River rises in Massachusetts to the north of Otis, and flows southeast for a distance of about thirty miles to Farmington. It there turns abruptly north to Tariffville, a distance of fourteen miles; finally bending to the east and southeast to enter the Connecticut River at Windsor. It receives many tributaries from the north, and certain large streams from the south and west. By an examination of the glacial deposits and the ancient valleys and the general structure of the region, we find that the Farmington has been very greatly modified, and that the course that it now holds is entirely abnormal. In pre-glacial time this river flowed from the vicinity of Congamuck Ponds directly south through Farmington, Plainville, Southington, and Cheshire, and entered the Sound at New Haven. The main tributaries from the west were the upper Farmington, which came down from Massachusetts through Colebrook, Barkhamsted, and New Hartford, and the Pequabuck, which came through Bristol. During the Glacial epoch, the entire river system was buried beneath the ice. As the ice sheet retreated, it left deposits of material at different places along the Farmington and its branches, which dammed the stream, and formed a number of lakes, interrupting the continuity of the river system. A lake was formed at Pine Meadow; the stream below that point was blocked, and found a new course for itself through the gorge at Satan's Kingdom. The pre-Glacial Farmington River was dammed at Cheshire, and was forced to give up its course to New Haven. It turned accordingly to the east, and carved the gorge of the Quinnipiac through a sandstone ridge at South Meriden. Another dam was built in the region of Southington, and a lake was formed extending through Plainville, Farmington and Avon. The lowest place in the rim of this lake was at Tariffville, and the stream was forced to take that roundabout way to the Connecticut River. Mill River and Quinnipiac River represent portions of the pre-Glacial Farmington, and the Northampton Division of the New York, New Haven & Hartford Railroad, which is built along the line of an old canal, runs for a large part of its course along the channel of the ancient river."

The first concerted effort for the improvement of the harbor was in 1870, though in 1852 there was an appropriation of \$6,000, when the need of breakwaters was agitated in the Chamber of Commerce by many prominent citizens, principally Captain Hervey Townsend, and resulted in a petition to Congress in 1873. This was favorably considered by the Committee on Harbor and Rivers, and an appropriation of 100,000 dollars recommended. In some mysterious way this item was erased from the Bill and nothing further was done until 1879. Then under the leadership of Mayor Bigelow, Captain Townsend and N. D. Sperry and others, a petition was circulated and presented to Congress by Congressman James Phelps, which appropriated the sum of 20,000 dollars and ordered a board of engineers to proceed to Long Island and after investigation locate and commence construction. Prior to this time the available low water depth from the wharves to Cranes Bar, one-third way down the harbor, was nine feet, thence to Fort Hale half way down it was sixteen feet or over. Below Fort Hale was a broad bar of soft mud extending across the channel with available depth of thirteen feet. The harbor entrance was partly obstructed by several sunken rocks, to remove which a project had been adopted in 1870, but afterwards abandoned when the new breakwaters were proposed. In Quinnipiac River the available low water depth was about four feet, and in the west branch of the Mill River about five feet to Grand Avenue.

This board, consisting of Generals Townsend, Newton, Abbot and Colonel Barbour, the engineer in charge of this District, recommended the construction of two breakwaters, which was approved January 31, 1880. Brigadier General Wright, Chief of Engineers, remarking that it ought to have been done fifty years before. This project was modified by act September 19, 1890, to construct four breakwaters, thus making a harbor of refuge at the mouth of New Haven Harbor. These were: one extending from Southwest ledge to Quixes ledge and 3,300 feet long; one from a point 1,000 feet N. 54° E. from Ludington Rock extending S. 54° W. across the Rock and 5,000 feet long; one extending northwesterly from a point 6,000 feet S. 54° W. from Ludington Rock and 4,000 feet long, and one extending southwesterly from Morgan Point on the east side of the harbor entrance and 1,200 feet long, at an estimated cost of 2,151,134.00 dollars.

In 1871 the project of deepening the harbor was adopted; the proposed depth and width being modified from time to time as appropriations were made until 1899, when the project provided for a channel sixteen feet deep and from 400 to 700 feet wide from Long Island Sound to the head of the harbor and for a dike to contract the channel across Fort Hale Bar. This project was completed with the exception of the channel arm of the dike, which was about two-thirds the projected length and the width of the channel across Fort Hale Bar, which was only 200 feet wide.

The last project was adopted by act of March 3, 1899 and provided for a channel twenty feet deep, 400 feet wide and four miles long from the Sound to Canal Dock; thence of same depth, 300 feet wide, one-half mile to Tomlinson Bridge, three anchorage basins below the bridge twenty, sixteen and twelve feet deep, a channel up Quinnipiac River 200 feet wide and twelve feet deep to Grand Avenue and one up the Mill River to junction above Chapel Street 200 feet wide and twelve feet deep and thence up each branch to Grand Avenue seventy-five feet wide and twelve feet deep, this act limited the work to the portion below Tomlinson Bridge, but it was extended by act of June 13, 1902, to include portion above, provided the cost did not exceed \$345,000. The above project was completed April 26, 1904, except that part of Quinnipiac from Ferry Street to Grand Avenue, where a channel fifty feet wide and eight feet deep was dredged.

By an act of March 3, 1905, a project adopted for the Improvement of the West River provided for a channel 100 feet wide and nine feet deep from the down stream corner of the sixteen feet anchorage basin in the harbor via Oyster Point and the dock frontage of West Haven to Kimberly Avenue bridge. This has been completed and in addition the nine-foot low water draft has been extended by private enterprise above Kimberly Avenue to the Railroad bridge.

The total amount appropriated for the widening and deepening of New Haven harbor and rivers and for maintenance of same from 1852 to date was \$634,073.90, of which about \$3,000.00 remains unexpended. The amount appropriated for the improvement of West River was \$38,500, of which about \$1,800.00 remains unexpended. The amount appropriated for breakwater construction at New Haven from 1879 to date was \$979,000, of

which about \$100,000 still remains unexpended, though contracted for. The amount estimated to complete project is \$1,172,134.00.

BRIDGES.

President Dwight's account mentions seven bridges in existence at that time. The Harbor, Dragon and Long Bridge over the Quinnipiac, the Neck Bridge over Mill River, Thompson's, the Derby Turnpike and West Bridge over West River. Of these the Harbor Bridge was the only one of any importance. Now we have Tomlinson's, Ferry Street, Grand Avenue and Lewis Bridge over the Quinnipiac, the first three being draw-bridges; over the Mill River, Chapel Street bridge, the two bridges at Grand Avenue, Neck Bridge and Rock Lane Bridge; of these Chapel Street is provided with a draw; and over the West River, Kimberly Avenue, which has a lift span, and fixed spans at Washington Avenue, Congress Avenue, Oak Street, Derby Avenue, Chapel Street, Edgewood Avenue, and Whalley Avenue.

WHARVES.

The wharves and docks deserve a separate paper for their description. Their history is filled with interesting events and its fascination grips one as he reads. We can scarcely more than mention them in the limits of this paper. Captain Hervey Townsend, the authority on New Haven Harbor and all pertaining to it, states that the site of Long Wharf was granted to Samuel Bache in November, 1663, it to extend fifty or sixty feet out on the mud flats. President Dwight states in 1806, "the last fourth of the wharf is incomplete at this time, but will be finished this season and is built entirely of stone. The other three-fourths is built of wood, sods and earth, its breadth for more than half its length is forty-five feet, and for the remaining thirty-two feet. It is 3,943 feet in length, more than twice the length of the Boston Pier, it is lined with warehouses and yards to the number of forty and is under the control of the Union Wharf Co."

In June, 1682 Thomas Trowbridge received a grant for a warehouse and wharf twenty-two feet wide and thirty feet from high water mark upwards and adjoining the Bache grant. These

were the only grants for wharves prior to the Revolution except two or three small, private landing places, and a large landing place at the foot of Meadow Street prepared for some Jewish merchants from Newport, R. I.; they not coming as expected it was sold to Prescott & Sherman, who conducted a large foreign and domestic business there. About 1848 the N. Y., N. H. & H. R. R., acquired a right of way across the above property and the Long Wharf to about the present junction of Cedar and Lamberton Streets and enclosing the area with an embankment, they erected a passenger station, machine shops and wharves. On the site of the present Water Street fire engine house there was a wharf previous to 1700. It was deeded by the town to the Fire Department in 1871. Adjoining, on the site of the present Railroad Office building, a grant was given by the Selectmen to Hezekiah Sabin to wharve 160 feet down the bank into the harbor, with the stipulation that he was to allow vessels to land fish, salt and wood, free. This wharf was sold to the New Haven and Northampton R. R. in 1869 by Governor English. About 1858 the Northampton Company received the right to use the bed of the Farmington canal, and incorporated in their charter the right to wharve off to the channel and constructed what is now the older part of Canal Dock. About 1790 the docks now occupied by Benedict, and DeForest & Hotchkiss, on Brewery Street, were built by Isaac Tomlinson and others. In 1800 the Proprietors Committee granted to Isaac Tomlinson, Kneeland and Isaac Townsend the right to build a sea wall six rods from high water mark, from Brewery Street to old Ferry Point, thus forming the present Water Street; they were also to maintain it. The Belle Dock was erected about 1840; prior to that time there was a wharf to the channel on the south side of Tomlinson Bridge. About the same date Heaton's Wharf was constructed by Colonel Moseley.

On the east side of the harbor and the river there was a wharf at Morris Cove erected by the Morris's about 1670, the Townsend Bros., the Wire Co's., Maltby's built in 1855 and Bigelow's in 1883. The grants for most all the earlier of these were from the Proprietors Committee of Common and Undivided Lands and the Selectmen, with such restrictions as we have noted above. Since 1874 all matters relating to the harbor have been in charge of the Board of Harbor Commissioners, which is composed of

five members, residents of the towns of New Haven, East Haven and West Haven, appointed by the Governor, and some of whose duties are:

To have general care and supervision of New Haven harbor and its tide water.

To prevent encroachments.

To remove obstacles to navigation.

To maintain maps, charts and plans of harbor.

To prescribe harbor lines after an advertised public hearing.

To approve location and plans of all wharves, piers, bridges, dams, piling or filling.

To demand compensation either by dredging or payment of a sum of money for amount of tide water displaced by any structure or filling.

To order suits of injunction at the expense of the city to prevent the erection of any work not authorised by them.

To apply to Congress for appropriations.

The Board of Aldermen and Department of Public Works have the authority to make, alter and repeal ordinances, subject to the approval of the Harbor Commissioners, to provide for laying out, discontinuing, altering, establishing and making public wharves, landing places, and slips below high water mark, within limits of the city. The city may take land for these purposes under the same method of procedure as for taking land for a highway.

SHIPYARDS.

The town shipyard, at the foot of Olive Street, prior to 1700 was probably the first of the many shipyards New Haven supported; though mention is made of the fact that many sloops were built at North Haven, on the Quinnipiac and conveyed to the Sound. Later there were also on the same river the Forbes Brothers and Gessners' yards. On the Mill River near the site of the Yale Boat House was the Post & Griswold's yard after its removal from Ferry Point. On the east bank of the West Creek near the foot of Meadow Street was Greenough's shipyard. Most of us remember the Hanscom yard on the Quinnipiac and the Sutton yard on West River of contemporary times. The last vessel built in New Haven was at this West River yard, the General Greeley. All of these yards at different times gave

employment to many men and turned out some famous ships. Their decline is to be regretted, as the passing of a picturesque feature of the water front.

SHIPPING.

It is very difficult to give any satisfactory account of the shipping of the port. Some of the coasting trade does not report through our Custom House at all, and this together with the Government method of classifying the data, makes it practically impossible to arrive at any very accurate conclusions, but the following figures will convey some understanding of it.

New Haven was made a port of entry by Section 4 of the Act of Congress March 2, 1799, but prior to that the Connecticut *Gazette* began to publish a report of the shipping in August, 1756; previously to that the reports were combined with those of other districts. Edward Randolph was probably the first Collector of Customs, Governor Leete being notified of his appointment, by the King, in 1681.

For the period 1783 to 1793, 706 vessels were reported from New Haven; from 1793 to 1803 the number was 600. Between 1798 and 1804 the tonnage was 28,065. There was a registered tonnage at the close of 1801 of 5,100, and enrolled 2,152; at the close of 1810, registered 4,486, enrolled 1,691. In 1807 there were sixty captains, residents of New Haven, engaged in foreign trade and sixteen in the coast trade. During this time the shipping was greatly affected by the embargo and other acts, and the different wars, restricting navigation.

Coming down to 1830, where the records are more complete, we find for the decade 1830-40 an increase in tonnage of sixty-one and five-tenths per cent., from 1840-50 an increase of thirty-six and eight-tenths per cent., from 1850-60 an increase of seventy and two-tenths per cent., from 1860-70 a decrease of forty-six per cent., from 1870-80 an increase of ninety-six per cent.; during the same period the number of vessels increased seventy-three and two-tenths per cent. From 1880-90 the tonnage increased eighty-eight and three-tenths per cent., the number of vessels fourteen and five-tenths; from 1890-1900, the tonnage decreased seven and eight-tenths per cent., the number of vessels seven-tenths per cent., and for the seven years from 1900-07 the decrease was fifteen and six-tenths per cent., and nineteen per cent., respectively.

Naturally this is only part of the problem. We do not know what proportion of the above was passenger and freight, nor do we know the relative movement of rail tonnage for the corresponding periods, nor how much they were influenced, by vessels being able to obtain better rates from other ports, by convenience in docking and clearing from this port, and the many other factors which enter into the problem. We do know, however, that the tonnage is not increasing at the present time; that it is directly related to the depth of water in our harbor and rivers; that vessels now draw as a rule eight to ten feet without cargo; that at eight to ten to sixteen feet they carry one-third or one-half a load, at sixteen to twenty feet they carry two-thirds or about double; that the last foot of draft represents the greatest carrying capacity and finally that in these days to move heavy commodities cheaply they must be moved in large quantities.

We see then that the history of New Haven's harbor and rivers and water front shows many changes. We have seen that the whole west of the harbor has been allowed to slip away from the control of the city, with the exception of the Public Wharf. Much of both sides of the Mill and Quinnipiac rivers, and some of the West River the same. They could not be taken back without a great expense to the city through condemnation suits, etc. For this condition no one in particular is to blame except a deficient public spirit.

It is interesting to compare the procedure under the New Haven Colony Charter and under the Dongon, Cornbury and Montgomerie charters of New York. Here we have seen that the grants for wharves, etc. were made without reservation except in one or two instances.

Under the above mentioned charters all vacant and unappropriated grants were reserved to the city. The city was granted lands under water for a distance of 400 feet outside of low water mark and had dominion over lands under water at the foot of streets. As a part compensation grantees were required to build not only their own improvements, but also a pier at the foot of the adjoining street, in which the city would hold half interest. The city could build the entire structure and retain all the wharfage, or could unite with others in building and retain part. The city, it is true, gave away many of its most valuable water front sites and was obliged to take them back later at greater expense.

but from the beginning there was in force a system safeguarding the city's interests.

The east side of the harbor is as yet open to the establishment of a carefully planned system of water front improvement and in the development of the easterly side it seems that the authority of the Harbor Commissioners should be extended, to permit them:

- To make contracts for dredging.
- To direct slips to be dredged.
- To establish bulk head lines.
- To establish pier head lines.
- To limit extent of solid filling.

And the city's power so extended to enable it:

- To regulate transfer of merchandise.
- To lease wharf property at public auction or privately.
- To grant permits for occupancy.
- To designate suitable and sufficient wharves for the use of the Departments of Public Works, Fire and Health.

We are at present in the throes of a public agitation over the further improvement of the Quinnipiac River, and our latest advice in the matter is that the Chairman of the Committee on Rivers and Harbors stands unalterably in the way of completing this work, because he thinks it partakes of the nature of a private enterprise and he feels that nothing further should be done for New Haven until her citizens have shown public spirit enough to spend some money of their own. This attitude of Washington need not occasion any surprise, for it is not at all new. From the time of Jefferson down, nearly every President has found it necessary to veto some Harbor and River bill. Particularly did President Jackson in 1830, President Arthur in 1882, and President Cleveland in 1896 deny the power of Congress to appropriate money for local or private benefit. But does this improvement sought by our citizens come in this category? We are accustomed to think of the city of Chicago as being quite new compared with our own city, but as early as 1833, forty-six years before New Haven, Chicago received an appropriation of \$25,000 and started work on the improvement of her harbor. Since then there has been spent on the harbor by the Government about \$2,201,000; and by the city, \$148,000; on the river by the Government, \$660,000; on the river by the city, \$6,000,000;

on the river by the Sanitary District, \$1,100,000; on the river by private parties, \$15,500,000; a total of about \$25,609,000.

So far as we are able to learn, the city of New Haven has expended nothing on the harbor and rivers. A very rough estimate indeed shows, however, that private interests have expended for docks and wharves about \$610,000; for dredging and redredging, \$186,000; value of land dedicated to slips, \$980,000; cost of bridges (does not include maintenance and repairs), \$960,000; a total of \$2,736,000. As against an expenditure by the Federal Government of \$630,000. These figures would tend to show, that the citizens are not without good reasons for urging their claims that the improvement of the Quinnipiac be,—not authorized, if you please, but completed as already authorized and planned for. It is very true that we are rapidly approaching a serious condition of affairs in our Harbor and Rivers appropriations. From the sum of \$2,000,000 appropriated in the Rivers and Harbor Bill of 1870, it has increased until the appropriation amounted in 1907 to \$87,013,432. It is true, also, that most Harbor and River Bills contain items that are for selfish local projects and that the Federal authorities are justified in scanning each item with jealous eye. Many Boards of Trade, Chambers of Commerce, and other municipal bodies have realized this and are bending their efforts towards a solution of the problem. And it may be, that it will not be long before we see a change in the methods of harbor and river legislation, nor would such a change be unwelcome to either the committee on Harbor and Rivers, the Secretary of War, or the Board of Engineers, who would be relieved from the many embarrassing situations which occur under the present system. Neither would it be unwelcome to New Haven, who should be able under a different system to obtain those further improvements in her harbor and rivers, which her size, geographical position, and I will say her public spirit, (for I believe that New Haven has a proper public spirit, which though apparently dormant now, awaits but a concerted effort to thoroughly arouse it), entitle her.

DISCUSSION—HARBOR AND RIVERS OF NEW HAVEN.

MR. VERRILL: There are one or two statements contained in Mr. Jackson's paper which I think need a little clearing up. The general impression made by his paper, I think, is that the

draft of vessels coming up to New Haven harbor is limited by the depth of water in the channel. That is not correct. I do not know that Mr. Jackson intended to convey that idea, but I rather got that impression myself and if others did I think it is an important misimpression. The draft of vessels entering New Haven harbor is governed not by the depth of water in the channel itself but by the depth of the water in the private slips. The depth of channel is supposed to be about twenty feet. It is actually only eighteen feet and vessels drawing eighteen feet can come in here very comfortably at low tide, but, there is no slip in New Haven with more than sixteen and a half or seventeen feet depth, and in fact most of them have twelve, thirteen and fourteen feet. I believe there are two with fifteen feet. Now as an actual matter of fact there is no vessel coming into our harbor with much more than that. I believe there are only five vessels that draw ten feet or more. These were lumber schooners or coal-carrying vessels, which constitute the larger number of vessels coming here.

There is another thing which has a bearing on this, and that is that the number is not limited by the channel, or, in this case, by the slips, but by the freight rates. When the freight rates are such that they can ship directly from Southern ports here, a good deal of freight comes that way, but the conditions are such now, and probably will be for some time to come, that most of the freight which is shipped here by water, is shipped from Jersey and New York ports and there is really no occasion for a depth of over twenty feet in the main channel. And that is what the Government has provided and will maintain. So I do not think that New Haven has any kick coming about the depth that the Government provides. Speaking as a general proposition, it is far better for commerce as a rule, and for the facilities of the harbor, that we have more water in the slips than there is in the channel. You can take advantage of the tide and bring a vessel through the channel having deeper draft than the channel ordinarily has. Under such circumstances where you take advantage of the tide you can bring a vessel into New Haven harbor drawing 24 or 25 feet without any difficulty. Whereas, about the deepest vessel that has ever come has been only about twenty-three. Of course, as I said before, by far the greater number of them that come in here are vessels of almost half that.

HYDRAULIC-FILL DAMS.

By Walter S. Morton, Mem. Conn. Soc. C. E.

The conveyance of material by the agency of water had its origin in the hydraulic mining regions of California. Through ditches and pipes streams were delivered under high heads and great pressure and directed against the face of the bank by a controlling device known as a "hydraulic giant" or "monitor," with a velocity of from 100 to 200 feet per second, which undermined, cut and loosened everything except hard rock and at such a small cost that hydraulic mines carrying but a few cents worth of gold to the ton were profitably worked.

This method has been successfully applied to the construction of the highest earth dams built in the world and at a surprisingly low cost, the water accomplishing all the work of the pick, plow, wagon or dump cart, and through a proper arrangement of the flumes, assorting, distributing and depositing the material at will and consolidating it to a degree impossible by the ordinary method of rolling and tamping.

The fundamental principles laid down by Mr. James D. Schuyler, member American Society of Civil Engineers, who has designed and supervised a larger part of the hydraulic-fill dams so far constructed, and applicable to any earth dam, as given in his excellent paper on "Recent Practice in Hydraulic-Fill Dam Construction," published in "Proceedings," October, 1906, are as follows:

1. The foundation must be of an impermeable character and have a water-tight connection with a rock or clay bottom upon which it rests.
2. It must be practically impervious to water in a whole or at least goodly portion of its entire cross section.
3. It must have slopes sufficiently flat to be stable under all conditions of saturation from the water in the reservoir or from soaking rains.
4. The crest of the dam must be sufficiently above the highest water line to insure against the possibility of overtopping by

extraordinary freshets or by waves driven up its inner slopes by gales of wind.

5. It must not settle, crack, or show any signs of change or movement after final completion and when put in service.

These requirements are fulfilled in the building of earth dams by the ordinary method of moistening, rolling and tamping, and the proper selection and distribution of materials, and by the exercise of great vigilance and care in construction, but at a much greater cost and with a more limited sectional area.

In general, hydraulic-fill dams are being constructed in the following manner:

A stream of water must be brought to a point adjacent to and above the top of the proposed dam under great pressure, either by gravity from a source still higher up, or by pumping from the stream below, the latter condition more commonly existing. In the case of very high dams there must also exist a bank of thirty or more feet in height lying above the dam site and not too great a distance from it. In dams of moderate height, not only the water, but the material can be obtained near the bottom of the dam and forced into the embankment by the use of sufficient power.

The stream conveyed to the borrow pit by means of pipes leading from the pump or from the gravity flumes terminates in short sections of hose attached to which are the monitors or controlling devices; the hose, generally, of four inches diameter, and the nozzles of two and one-half inches diameter or less. The nozzles are brought within twenty to fifty feet of the face of the bank and directed against it at the bottom. The pressure at the nozzle should not be less than seventy-five pounds per square inch, and preferably more. This powerful stream undermines the bank, loosens and disintegrates the material, moving even boulders of large size. Leading from the foot of this bank to the embankment is a wooden flume of rectangular cross section or a riveted steel pipe. This conveying flume, or pipe, is generally laid along the longitudinal axis of the dam and tapped at intervals over the dam site by lateral flumes. The conveying flume must have a grade sufficient to carry the water without depositing within it the material held in suspension and which has been washed into the flume from the borrow pit.

Sometimes two flumes are used, one over each edge of the embankment.

The material carried by the water is in all cases discharged at the ends of the laterals, and is first deposited on the up and down stream edges of the embankment. This serves two purposes: first, depositing the coarser and heavier particles on the outer edges, and second, keeps the outer edges at a higher elevation than the interior.

A shallow pond is thus maintained in the central part of the embankment by means of the higher rim and into this pond accumulates the finer, silt-like particles conveyed in the sluiced material, which gradually settle and deposit and thus form a large center core of fine, impervious material, puddled and compacted by the action of the water into a dense mass which constitutes the water-tight portion of the dam, the heavier particles deposited on the outer slopes serving to hold it rigidly in place. Thus by a proper manipulation of the flumes the materials are assorted and graduated in size from the outer edges towards the center, and in a far more exact manner than can be done under the ordinary process of dam construction, and forms one of the essential features of hydraulic-fill dams. The surplus water is drawn out of this pool near the surface by suitable wooden drains or pipes.

Several methods are used in maintaining the proper slopes of the sides of the embankment. In some cases small, dry embankments are constructed by teams or scrapers, or by the piling up of loose rock to confine the sluiced-in materials. In others, layers of brush are placed on the outer edges which fill with sediment and form a water-tight rim. The method pursued by Mr. E. H. McHenry, while chief engineer of the Northern Pacific Railroad, and now vice president of the New York, New Haven & Hartford, was that of sprinkling loose hay along the edges of the embankment, upon which was placed a small layer of earth to hold it in position. The sluiced material quickly filled the loose hay and made a water-tight edge. This method was not only simple and inexpensive, but through the subsequent sprouting of the hay into a rank vegetable growth gave additional protection to the slope after completion.

Another form of dam has been built consisting of a combination of a loose rock-fill backed by a deposit of earth placed in

position by the sluicing process. In this form of construction a diaphragm of two inch plank was placed in the center of the rock-fill and made water-tight so as to prevent the sifting of the finer material through the loose rock and its subsequent loss while still in a liquid state; the depositing of the material by sluicing being done in the manner heretofore described, the coarser particles being deposited on the upstream edge and the finer against and adjacent to the rock-fill.

The conveying flume reaching from the borrow pit to the dam site should have a grade of at least three per cent. and steeper when obtainable. The heavier the grade the greater the velocity of the water and the constant increased carrying capacity. In order to carry coarse gravel and rock it should have a grade of from six per cent. to seven per cent. Grades as high as twenty-five per cent. have been used, but in general one of six per cent. is sufficient. Effective work has been done with those as light as three per cent., but with such a light grade the flume is likely to become clogged and fill up through any accidental diminution in the water supply.

Flumes are constructed in many cases of steel riveted pipe of a diameter of sixteen to twenty-two inches. Steel pipe under the abrasion of the swiftly moving material is apt to have a short life. Wooden flumes, rectangular in shape and constructed of inch boards, twelve inches wide, and with a false bottom which can be replaced when worn out, seem preferable. They are of less initial cost and of equal if not greater durability. This style of flume generally has an inside dimension of ten inches by eleven inches. The flume has a top until the dam site is reached, where it is left open. The laterals are placed at right angles to the main discharge flume and receive their supply from the bottom and are laid on the same grade or steeper than the main flume. The flumes are supported by temporary trestle work which is generally buried in the dam.

The capacity of the pumps required to force the water through the pipe and to give sufficient pressure at the nozzle to be effective varies with local conditions, the amount of water desired to be delivered, the aggregate volume of the material to be moved, and the rapidity with which the work must be accomplished. Pumps with as small a capacity as 1.76 cubic feet per second have been used effectively up to pumps delivering from seven to ten cubic

feet per second. Mr. McHenry states that a pump of 1,000 gallons per minute capacity and with flumes laid on a six per cent. grade should move 1,000 cubic yards of material in ten hours when the lifting head is not too great. In general, it is possible to obtain second-hand pumps and boilers which should be sufficiently effective, as the duration of the work is short and high duty not necessarily essential.

The rapidity with which work can be accomplished by this process is surprising. In numerous cases material has been deposited at the rate of from 1,000 to 2,000 cubic yards and over per day, a feat impossible of accomplishment by the ordinary method of dam construction within the restricted area of an embankment, where the material must be assorted, distributed and placed in thin layers, moistened and rolled. Under these conditions a few hundred yards constitutes a big day's work.

In the construction of the Lake Francis dam, California, 195,293 cubic yards were moved, deposited and assorted in 1,581 hours of actual sluicing time, with a pumping capacity of four and one-half to seven cubic feet per second, a conveying flume of twenty-two inches in diameter laid on a three per cent. grade. It is estimated that 30,740,000 cubic feet of water were moved, depositing 4,940,000 cubic feet of solids or 16.6 per cent. of solid matter to water. A ratio of solid matter to water when everything was running smoothly ran from thirty-two per cent. to thirty-eight per cent., highest, 47.7 per cent. The highest weekly average was 443 cubic yards per hour, 4,430 cubic yards in ten hours; mean, 123 cubic yards per hour. The water pressure at the pump was 118 pounds per square inch. The maximum power used was 320 horse power; mean, 236 horse power. Total power, 410,800 horse power hours, costing one-half cent per horse power hour, equal to one cent per cubic yard of material moved. This was a low cost per horse power hour, as the power was delivered electrically from a nearby water power plant. The work was more or less handicapped by the interrupted supply of power. The cost of moving material by the hydraulic process varies from two cents per cubic yard to twenty cents, depending upon conditions of uninterrupted, constant power, proper gradients in the delivery pipe giving high velocities, and ability to move larger proportions of sand, gravel, and broken spalls of stone, and the rapidity of work which reduces the labor cost and fixed charges.

Suction dredges, where the principle involved is the same, and which are in common use along the Atlantic Coast, have sucked material from the bottom, forced it from 2,000 to 4,000 feet through pipes and placed it in banks eighteen to twenty feet above the water at a cost of two cents per yard. The general cost of this class of work runs from four to six cents per cubic yard. The cost of sluicing in the Lake Francis dam above mentioned was twenty cents a cubic yard. Mr. Schuyler, who had engineering supervision of this work, states that with uninterrupted delivery of power and other conditions generally found more favorable elsewhere, this work could not have been done for but a fraction of this cost, possibly as low as five cents per cubic yard. The Tyler dam in Texas, built some fifteen years ago, consisting of 24,000 cubic yards of material, cost but \$1,140 in all, including the spillway, outlet gate and pipe, an average of four and three-fourths cents per cubic yard. The pump had a capacity of 520 gallons per minute, nozzle one and one-half inches in diameter, water pressure 100 pounds per square inch. The material moved was sixty-five per cent. sand and thirty-five per cent. clay.

The Western Brick Company of Danville, Illinois, for some five years back, have been stripping the sand and gravel over their shale bed, which runs from three feet to sixteen feet in thickness by the hydraulic process. The material is moved 1,600 feet, the flume gradient being three per cent. The water is pumped 4,000 feet through a ten inch pipe, the pressure at the nozzle varying from seventy-five to one hundred pounds per square inch. About 2,000 yards are moved daily. But four men are employed, two at the nozzles, one fireman and one engineer. The cost is two cents per cubic yard.

Many thousand yards of material were moved by the hydraulic process and embankments filled by the Canadian Pacific Road. One of these embankments was 231 feet high and contained 148,000 cubic yards. The average cost was but 7.24 cents per cubic yard. But eight men were employed, one piper at monitor, one sluice box man, two flume men, three men on dump and one foreman. The fill was made without interrupting the train service. The average amount moved in ten hours was 1,560 cubic yards. The distance moved, nearly 1,200 feet. Water was supplied by gravity. In another fill made by the same company of 400,000 cubic yards, the average cost was 5.59 cents per cubic

yard, and eight cents per cubic yard including the cost of the plant. Flume grade, eight per cent. Some 600,000 cubic yards were moved by the Northern Pacific Railroad at an average cost of 6.39 cents per cubic yard, or 5.82 cents for labor and .57 cents for material. Some fifteen trestles on the Cascade division were thus filled by this company under the direction of Mr. E. H. McHenry, the cost running from 3.8 cents for the lowest and 30.24 cents for the highest, the latter being but 800 yards and the former 53,600 yards. The largest amount in any one fill was 158,000 yards, which cost 5.19 cents per cubic yard. The average cost of moving 377,000 cubic yards was 4.79 cents. The details of which are as follows:

Sluicing and building side levees.....	3.89	cents	per	yard.
Hay used in side levees	.09	"	"	"
Tools	.08	"	"	"
Lumber and nails.....	.22	"	"	"
Labor building flumes.....	.44	"	"	"
Engineering and superintendence.....	.11	"	"	"
Total.....	4.79	"	"	"

NOTE.—Water was supplied by gravity.

In general an estimate of fifteen cents per cubic yard would seem ample unless conditions were very unusual. The preparation of the foundation would be the same as that for any earth dam construction. However, if sufficient rock of sizes that could be moved through the flume is deposited on the up-stream face of the dam, less expensive paving for protection against wave action can be used. This estimated cost of fifteen cents per cubic yard is from a quarter to a third the cost of constructing a dam by the usual methods of wagons, spreading, moistening and rolling.

An eminent authority has said: "No type of construction that man builds to confine water can compare in permanency with earth dams."

Earth dams have a well-defined history running back some 2,500 years, and there are earth dams in efficient use to-day hundreds and hundreds of years old, and yet there seems to be no subject more prolific of controversy and upon which engineers so widely differ as to their best design and construction. New England engineers have a practical interest in this form of con-

struction where many reservoir dams are built, often lying in hollows with high banks above the dam site, and there are instances where it may be well worth while in the interests of economy as well as that of efficiency and durability to consider the application of a hydraulic-fill rather than the expensive construction now in vogue. In one earth dam of a height less than fifty feet built by me where excellent material was found within 500 feet of the dam site and where the specifications called for layers not exceeding three inches in thickness, the contract price was *over sixty cents per cubic yard*, and yet the contractor made no excessive profit on this very large figure. The dam was so well compacted by rollers as to cause an expenditure of nearly \$2 per cubic yard for the excavation of a small trench therein.

Mr. Schuyler, in speaking of the hydraulic-fill process, says:

"It cheapens the cost of handling and compacting earth in dams so greatly as to extend widely the practicable limits of dam building, by making it feasible to increase the bulk of any dam far beyond the usual dimensions, without exceeding reasonable limits of cost."

Mr. Burr Bassell, author of an excellent work on "Earth Dams," and under whose engineering supervision the Tabeaud dam of California was constructed, the highest earth dam built in the United States by the usual methods, says, in speaking of hydraulic-fill dams:

"Water performs the work of loosing the earth and rock in the borrow pit as well as subsequently transporting them to the embankment and there to sort and deposit them and finally to part company with them after COMPACTING THEM SOLIDLY IN PLACE EVEN MORE FIRMLY THAN IF COMPRESSED BY HEAVY ROLLERS."

It must be remembered that it is impracticable to compact clear sand or gravel to any degree without the admixture of some binding material by the use of rolling and tamping, whereas by water this material is reduced to a very dense mass.

The more prominent dams constructed by the hydraulic process are as follows:

Lake Francis Dam, California.

Crane Valley, California.

Snake River, Idaho (three dams).

Dam in Hawaiian Islands.

New Mexico, built by the United States Indian Bureau.

Terrace Dam in Colorado, highest earth dam in the United States. Necaxa and Tenango in Mexico, the former the highest earth dam in the world, 180 feet high.

Tyler Dam, Texas.

Le Mesa Dam, California.

Lake Christine Dam, California and the San Leandro Dam, California.

These dams run from forty-six to 180 feet in height, top widths twenty to twenty-five feet, up-stream slope generally three on one; down-stream slope two and two and one-half on one. Some of them are combination dams, part loose rock-fill backed by sluiced in earth. Rock-fill has a slope of 1.5 on one on the down-stream side and three-fourths on one on the up-stream side with a top width of ten feet. The materials composing the dams are mostly sand, gravel, rock, with the interior core of fine sand, clay and in some cases even quicksand and the impalpable wind-borne soil of Snake River Valley, Idaho and volcanic dust.

The Necaxa dam of Mexico has a height of 180 feet, 950 feet base and contains some 2,000,000 cubic yards of material. It is the highest and largest earth dam ever built and was constructed throughout by the hydraulic-fill process.

DISCUSSION—HYDRAULIC-FILL DAMS.

MR. RYDER: I wish to say just a word about the Necaxa Dam in Mexico mentioned by Mr. Morton. It was under construction last spring when the American Society of Civil Engineers visited it. In order to get the water for the hydraulic sluicing they built a canal, some eleven miles long, and when the water reached the point where they wanted to use it in tearing out the material to be conveyed to the dam they had a head of 450 feet. They used four-inch nozzles and had two streams going at the same time. The force of the streams was tremendous and we can well agree with Mr. Morton that the adoption of such a plan for excavating material is certainly very economical. The dam is not nearly completed to its full width, or was not at that time, but it is on the way to be. It is being constructed by Canadian engineers.

MILL ROCK WATER TOWER, NEW HAVEN, CONNECTICUT.

By Edward E. Minor, Mem. Conn. Soc. C. E.

The New Haven Water Company constructed during the last year a reinforced concrete water tower on Mill Rock, a brief description of which it was thought might be of interest to the members of the Society. The purpose of the water tower was to provide, in case of necessity, a means whereby water could be supplied to the high pressure service in the city, independently of its usual source of supply.

The high pressure service covers what is known as Prospect Hill, and is supplied by gravity from an impounding reservoir, Lake Wintergreen. This lake is situated on the easterly side of West Rock Range at an elevation of about 240 feet above mean high water in New Haven harbor, which is city datum.

Mill Rock is a precipitous trap rock ledge, lying just north of the Whitneyville pumping station and near Prospect Hill. The water tower is located on the highest point of the ledge. Its elevation underside of roof girders is 246 feet above city datum. The tower is connected with the high pressure service and with the Whitneyville pumping station. The former connection is usually open, the latter closed. The function of the tower then consists in storing the water during the night, when the draft is light, and feeding it out during the day as the consumption increases, in effect much like a fly wheel on an engine. There remains, as already spoken of, its ability to altogether replace the Lake Wintergreen supply, if desired.

There were certain requirements, arising from its location and surroundings, which made it necessary so to construct the tower that it might be used as an observatory. It is covered by a flat, concrete roof, around which is a parapet wall, and leading up to the roof, an iron stairway. The stairway is located in a small octagonal tower adjacent to the water tower and opening out upon the roof.



ROOF OF WATER TOWER.



FILLING FIRST SECTION OF WALL TOWERS.

The water tower is 50 feet in diameter and 25 feet in clear height to the underside of the roof girders. The walls are vertical, 18 inches in thickness, and reinforced with round, steel bars ranging in size from $1\frac{1}{4}$ to $\frac{1}{2}$ inch in diameter. The bars came in lengths of about 30 feet, and are lapped about 3 feet and fastened with four Crosby wire rope clips at each joint. They are spaced uniformly 5 inches on centers, being fastened to 2×2 -inch vertical spacing angles 5 feet apart.

The roof is supported by four reinforced columns, 18 inches square, across which run beams 12 inches in width, and varying from 12 inches to 16 inches in depth; the bottom of the beams being level and the pitch of the roof, four inches, being formed by the top of the beams. They are reinforced by four $\frac{7}{8}$ -inch square, twisted steel bars and $\frac{1}{2}$ -inch square stirrups. They divide the roof into panels about 16 feet square. The roof slab is 8 inches in thickness and reinforced by $\frac{1}{2}$ -inch square, twisted steel bars, 6 inches on centers each way. The beams and roof slab are reinforced as acting continuously across points of support and were put in at one time.

The side walls were built in lifts of 6 feet in height. Two complete sets of forms were used, and when the upper set was filled, the lower one was taken out and set up on top. Each form unit was 6 feet in height and about 12 feet in length. When these were set up, they were held very accurately in place by battens spiked to uprights set inside the tower about five feet away from the wall. These uprights formed a rigid tower inside the water tower and were used not only as a temporary support for the wall forms, but for a working platform as the walls were carried up, and later as part of the staging for the roof forms.

The inner and outer forms were held by $\frac{3}{4}$ -inch bolts, the center section of the bolts with two sleeve nuts being left permanently in the walls. One set of wall forms was built over into the forms for the corbel course running around the top of the tower, and the other into the forms for the parapet.

The tower is located on top of a rocky ledge about two hundred feet above the road. A narrow gage incline cableway was built, having a grade of about 50% in the steepest place, and running from the concrete plant at the base of the rock to the water tower. All concrete was mixed at the bottom. The track ran below the mixing plant, which was set well up in the air



TOWER, SHOWING WALL FORMS IN PLACE.



MILL ROCK WATER TOWER.

with large hoppers for all materials. A one-yard Smith concrete mixer was used. The buckets, mounted on small cars built up for the grade, were run under the mixer, loaded, and hauled to the top by a two-drum Lidgerwood hoisting engine. At the top, two stiff-leg derricks, set so as to command practically all sides of the tower, lifted the concrete to place. For the walls a three-sided box was built, set on wooden rollers, and the buckets dumped into this. In this way a cubic yard of soft concrete was placed in the walls easily and quickly and the box kept traveling along the walls at a good speed.

A wall section would be taken off and reset above in two days. It would take one day to fill it. The old surfaces throughout the work, where new concrete set on old, were picked and then thoroughly cleaned with a steam jet. Great pains were taken to have old surfaces well cleaned and to have all concrete thoroughly spaded.

The concrete above the foundation was mixed in the proportion of 1-2-4. Vulcanite cement was used, crushed trap rock passing a 1½-inch hole, and sand having a uniformity coefficient of about 3.5. The tower has been filled for several weeks and has proved practically tight. On the southerly side for a short distance there appears some seepage at the joints. This is sufficient to dampen the surface of the concrete for a width of about 3 inches. Elsewhere the surface appears dry.

The contractors were the New York Continental Jewel Filtration Company, Mr. John G. Munson superintendent. The work was planned and the construction carried out for the New Haven Water Company under the direction of Albert B. Hill, consulting engineer. The writer was engineer in charge. The inspector was Fred L. Coe, of Mr. Hill's office.

DISCUSSION—MILL ROCK WATER TOWER.

MR. DENMAN: One of the points that has been touched on in this paper brings up a subject of interest that has caused a good deal of discussion. I saw recently the Turner Construction Company finishing a floor and they had adopted a method in finishing it which seemed to give a very good result. The floor is put in and then they treat the top of the floor with a layer of muriatic acid (d) and then thoroughly wash it off. The method seemed to give very good results.

"SNAP SHOTS IN AMERICAN CITIES."

By Frederick L. Ford, Mem. Conn. Soc. C. E.

Mr. Frederick L. Ford of Hartford gave a most instructive and interesting talk, entitled "Snap Shots in American Cities." We are able to give only a synopsis of it here.

It presented many new and advanced methods for promoting the public convenience, safety and health, and the ornamentation of city streets, parks, etc. He showed many views illustrating up-to-date methods of lighting streets in many of the principal cities of the country, like New York, Syracuse, Buffalo, Cleveland, Chicago, Minneapolis, St. Paul and other places. Also methods of setting trolley poles, the use of combination trolley and electric light poles for street lighting purposes, the regulation of the rays from street lamps so as to throw the lights more on the sidewalks than upon the highways, the grouping of electric and gas jets so as to secure more effective lighting and also different appliances and methods of ornamentation for lamp-posts and the lamps themselves.

Mr. Ford also showed pictures of different designs of "Isles of Safety," as they are called, or places in crowded thoroughfares where pedestrians may stop and be out of danger from the traffic in the street. He also showed different views illustrating methods of handling trolley traffic, the lay-out of the trolley tracks, the erection of the trolley poles in a strong and artistic manner. Also views illustrating the condition in certain streets arising from the abuse of the right to erect overhead wires, and views illustrating the difference in those same streets after the wires were removed. Also pictures showing the difficulties which firemen have in fighting fires in streets along which are extended a large number of overhead wires.

He also showed a number of views of artistic and neat appearing public comfort stations as erected in some of the prominent cities of the west and south, and commented with deserved severity upon the backwardness of our eastern cities in establishing such places. He also showed some views illustrating the interior arrangement of such stations, and the methods used to secure payment for conveniences furnished, and the proper use and care of the conveniences provided.

A series of views showing different types of standard garbage carts as used in various cities were all of interest to the engineers present, as were also the different methods which were illustrated for the collection and disposition of garbage. Pictures showing the different methods of flushing and cleaning the streets, cans for the reception of waste usually thrown into the streets, and the method of carrying ashes as used in the city of Brooklyn and carting them away by the use of trolley cars, to be used in filling in low land, were also much appreciated.

The picture of an apparatus for enabling a motorman to see people climbing upon the car at the rear so as to guard against accidents from starting the car too soon was of especial interest.

Mr. Ford also showed some views of illuminated signs as used upon trolley cars, also views showing different types of trolley cars in use in Des Moines, Iowa, and in Minneapolis; also some cars designed to climb over heavy grades, and a type of car used between Providence and Fall River. Also some views showing the different styles of trolley stations in use in Boston, Cleveland and other places at transfer points, showing how such buildings could be made readily adaptable for both summer and winter and at the same time affording complete protection from inclement weather for those compelled to wait at such points. The views shown by him illustrating the working of a temporary bridge erected over the rails of the trolley tracks in Springfield, in cases where a fire hose in use at a fire was stretched over the rails so that traffic might not be interrupted, were of great interest.

Many other views shown by him, such as those of illuminating signs for public streets, the catch basins used in Milwaukee, the traveling blacksmith shop used by the fire department of the city of Rochester, and also those of private residential streets which have received artistic treatment in some cities, were all highly enjoyed. Mr. Ford's description of these private residential streets as being virtually little towns by themselves within the large towns was a new idea to many of his listeners.

A series of views showing the methods of illuminating these private residential streets, also of the entrances to various private parks and exclusive enclosures of the kind referred to, were of much interest.—Ed.

RICHARD MILFORD BERRIAN.***In Memoriam.***

Richard Milford Berrian was born in New York City on May 17, 1850. After an education in public and private schools of New York he began his engineering work in 1869 as draughtsman in the offices of the New York and Harlem Railroad Company and was largely engaged on the designing of the old Grand Central station. Two years later he was made assistant engineer in connection with the Grand Central work and in 1872 he was put in charge of a portion of the Fourth Avenue tunnel as division engineer. On the completion of this work in 1876 he was engaged in various works: on the survey and construction of the Manhattan Beach Railroad as assistant engineer; on the Boston, Hoosac Tunnel and Western Railroad as division engineer and later chief engineer; and on the Buffalo Division of the New York, Lackawanna and Western Railroad as division engineer in charge of construction and location, besides much minor work.

In 1890 he entered the engineering department of the New York, New Haven and Hartford Railroad as assistant engineer of construction; rebuilt the Shaw's Cove and Niantic drawbridges; built the four track improvements through South Norwalk, including South Norwalk four track drawbridge; built the four track Boston and Providence extension, Boston, connecting the Providence Division with the South Terminal, in addition constructing the great six track lift bridge across Fort Point Channel; built the four track elevation through Bridgeport, including the four track lift bridge over the Poquonnock river, the open caisson for the center pier being probably the largest caisson ever constructed, measuring some 65 feet by 92 feet; planned and started the double track improvements on the Naugatuck Division from below Derby to Waterbury; constructed the four track lift bridge over the Connecticut river at Saybrook, the construction of the foundations for this latter bridge by open caisson in an exposed roadstead being a most bold and successful feat, pier No. 5, built in 43 feet of water, having what is probably the deepest open caisson ever used.

On the completion of this latter work he took charge as chief engineer of the construction of the joint state and county bridge over the Taunton Great river at Fall River, and was in charge of this work when his death occurred, December 23, 1907.

Richard Milford Berrian was unquestionably one of the ablest engineers of the day, and in his professional career solved many engineering problems of the first magnitude, but with characteristic modesty he would never consent to publish any accounts of his work. Combining with remarkably full technical knowledge of the principles of engineering a thorough practical knowledge of construction work, and joining to this the instinct of the born contractor for organization of labor, Mr. Berrian worked out his plans in the most complete detail, not alone as respecting the employer's side of the case but with reference as well to the limitations and necessities of the contractor, with a resulting harmony of action by the various interests which secured the best possible results. Seeing clearly far in advance the various steps of the work and the relation of all concerned in it to the work and each other, Mr. Berrian insisted on absolute and prompt compliance with his instructions, but he was as quick to commend good work as to reprimand failure to carry out his well-laid plans. He held the fullest respect, confidence and admiration of all who came in contact with him. He was a member of the American Society of Civil Engineers and of the Connecticut Society of Civil Engineers. In his death the profession loses one of the greatest engineers of the times.

CHARLES RUFUS HARTE,
CURLYS L. SLOCUM.

CHARLES FRANCIS POWELL,

Brigadier-General, U. S. Army, Retired.

In Memoriam.

General Powell was born in Jacksonville, Ill., August 13, 1843, and died at St. Paul, Minn., July 30, 1907.

His early education was in the public schools of Milwaukee, Wis. When the Civil War began and before he was eighteen years of age he began his military career, enlisting May 10, 1861, as a private in Co. B, 5th Wisconsin Volunteers; was promoted to Corporal and then to Sergeant Major, and while serving in the latter capacity was appointed a cadet at the U. S. Military Academy by President Lincoln, September 29, 1863. He graduated from West Point and was commissioned Second Lieutenant, Corps of Engineers, June 17, 1867; was promoted to rank of First Lieutenant in 1875, to Captain in 1896, to Major in 1901, and to Lieutenant Colonel January 22, 1904, all of the foregoing being in the Corps of Engineers. On March 31, 1906, he was commissioned Brigadier General, U. S. Army, and on April 3, 1906, he retired from active service under the provisions of Section 1244, Revised Statutes, he having reached the age of sixty-two years.

General Powell's record during the Civil War was a brilliant one, and it was for gallantry on the field of battle that President Lincoln appointed him a cadet at West Point, and mainly on account of his war record that he finally received his commission of Brigadier General, U. S. Army. The writer is not conversant with the details of his service during this war, for General Powell's natural modesty prevented his saying but little about it, but I once heard him say that he had two or more horses shot under him and his cap carried away by a rifle ball, but that he was never actually wounded.

While an officer of the Corps of Engineers his duties were many and various, and during that period he was at different times engaged in nearly all the duties pertaining to Civil and Military

Engineering. He served with the Battalion of Engineers; as Assistant Engineer on the Geodetic Survey of the Northern Lakes and of the Mississippi River; as Engineer of the Thirteenth Lighthouse District; as Secretary and Disbursing Officer of the Mississippi River Commission; as Engineer Commissioner of the District of Columbia; and as Engineer of several fortification and river and harbor districts. Among the more important river and harbor works of which he had charge may be mentioned the Cascades Canal, Columbia River, Oregon; the improvement and survey of the Missouri River; and the Monongahela River slack water navigation system. On January 8, 1902, he assumed charge of this district, comprising all river and harbor improvements in Connecticut and the Pawcatuck River between Rhode Island and Connecticut, and also the defences at the eastern entrance of Long Island Sound. He remained in charge of this district, with headquarters at New London, Conn., until March 8, 1906, when, on account of a serious illness, he was obliged to give up work, and very shortly afterwards retired from active service.

Throughout his professional career all of General Powell's duties were well and faithfully performed, and he always gave to his work the most unremitting personal attention, even to the smallest detail. Personally he was of an extremely kind and courteous disposition and devoted to his family.

He was married May 17, 1883, at Albany, Oregon, to Margaret, daughter of James H. Foster, and is survived by his wife and six children.

He was elected a member of the American Society of Civil Engineers on October 3, 1888, and of the Connecticut Society of Civil Engineers, February 10, 1903.

GEORGE E. VERRILL.

ABSTRACT OF THE PROCEEDINGS
AT THE
TWENTY-FOURTH ANNUAL MEETING
OF THE
Connecticut Society of Civil Engineers.

Convention called to order at 11.30 A. M., in North Sheffield Hall, Yale University, President Daniel S. Brinsmade in the chair.

It was voted to accept the minutes of the previous meeting as printed in the annual report.

Secretary Jackson read the report of the Board of Direction as follows:

REPORT OF THE BOARD OF DIRECTION.

A meeting of the Board of Direction was held at Hill's Homestead, West Haven, on July 10, 1907, at 4.30 P. M., at which time the following business was transacted.

The consideration of the Haupt resolution was referred to a sub-committee appointed by the President. Three members were dropped from the rolls. The dues of one member were remitted up to January 1. It was voted that the Summer Meeting consist of an excursion up the Naugatuck Valley to Waterbury and back by way of Cheshire, the arrangements to be left to a committee appointed by the President. The sum of \$100 was appropriated for expenses.

At a meeting held at Scott's in Cheshire, August 14, 1907, the following applications for membership were approved: Charles B. Brown, Horatio Bigelow, Louis Hudson, Hinman B. Hurlburt, Frank H. Lines, Alexander S. Lynch, Claude A. Magill for active membership, and Henry B. Lanwett for associate membership.

At a meeting held in the City Hall, New Haven, January 3, 1908, the ballots for nomination of officers were canvassed with the following result:

President, Edward W. Bush, Hartford.

1st Vice President, Frederick J. Easterbrook, New Haven.

2d Vice President, Francis H. Oldershaw, New Britain.

Secretary and Treasurer, J. Frederick Jackson, New Haven.

Directors, Geo. K. Crandall, New London; John K. Punderford, New Haven.

The resignations of F. Irwin Davis, Louis Hazletine and Edwin M. Lee were accepted, one member was reinstated, and two members dropped.

The Committee on Haupt Resolution made the following report, which was adopted by the Board:

"In the matter of the resolution indorsing state control of waterways, which was considered at the last annual meeting and referred to Board for consideration, the Board of Direction respectfully reports as follows:

That they have considered this resolution and do not urge its adoption by our Society because:

The general topography of this state is such that a comprehensive system of canals and waterways could not readily be built, and even if built, would be of doubtful utility.

That further legislation is not required to permit the chartering of any company desiring to organize to promote interior navigation. In fact, such a company on the Connecticut River is already in existence, and at the present time maintains a dam and locks for interior navigation, although the same have not been used to any extent for many years past. That in this state, the extension of waterways connecting with salt water can best be made and maintained by the national government.

That while we may be in sympathy with what might be done in other states to extend waterways under state control, it is not within the scope of this Society to urge their adoption elsewhere.

Signed,

EDWARD W. BUSH,

H. J. KELLOGG,

Committee."

It was voted to hold the annual meeting at New Haven, that it be a two days' session, and that the arrangements be left in the hands of a committee, to be appointed by the President; that the sum of \$150 be appropriated; that the publication of the Bulletin be dispensed with; that a sub-committee be appointed by the President to audit the books of the Treasurer before the annual meeting.

Signed,

D. S. BRINSMADE,

HENRY J. KELLOGG,

J. K. PUNDERFORD,

EDWARD W. BUSH,

GEORGE K. CRANDALL,

F. J. EASTERBROOK,

CHARLES F. CHASE,

Board of Direction.

Attest:

J. FREDERICK JACKSON, *Secretary.*

It was voted that the report be accepted and printed in the proceedings. Report of the Secretary read by Mr. Jackson as follows:

REPORT OF THE SECRETARY.

To the Officers and Members of the Connecticut Society of Civil Engineers:

Your Secretary respectfully submits the following report for the past year:

In June, fifteen hundred copies of the twenty-third annual proceedings were printed and distributed to the members, to those societies with whom we exchange, and to different libraries and institutions of learning.

The Society held an additional meeting on August 14, a trip up the Naugatuck Valley to Waterbury, and back by way of Cheshire, which was thoroughly enjoyed by those present.

The Secretary has during the year attended the different meetings of the Board of Direction; has had printed and distributed notices of the different meetings, bills for dues and advertising, and the ballots for nominations and election of officers. The canvass for nominations resulted as stated in the Report of the Board of Direction.

During the year twenty-nine new members have been elected: one honorary, twenty-seven active, and one associate. Ten active and one associate members have resigned. Five have been dropped. John W. Bacon, Major Charles F. Powell and Richard M. Berrian have died. The membership on February 10, 1908, is as follows:

	Feb. 11, '07	Transfers	Elections	Resigned	Dropped	Died	Feb. 10, '08
Honorary	11		1				12
Active	256		27	10	5	3	264
Associate	8		1	1			8
		275	29	11	5	3	284

It was voted that the report be accepted and printed in the proceedings. Report of the Treasurer read by Mr. Jackson as follows:

REPORT OF THE TREASURER FOR THE YEAR ENDING FEBRUARY 10, 1908.

J. Frederick Jackson, Treasurer, in account with the Connecticut Society of Civil Engineers.

RECEIPTS.

To cash on hand, February 11, 1907	\$782.91
Received from advertisements, 1907	446.65
Received from back dues	81.00
Received from dues, 1906	141.00
Received from dues, 1907	369.00
Received from dues, 1908	159.00
Received from sale of dinner tickets	223.50
	<u>\$2,203.06</u>

DISBURSEMENTS.

By Cartage	\$.50
Expressage	63.87
Freight	2.44

Expense, annual meeting	\$ 267.85
Postage	.40
Printing, stationery and supplies	1074.31
Rent of P. O. box	6.00
Engraving	254.90
Services of stenographer at meetings	40.00
Salary, Secretary and Treasurer	150.00
Summer meeting	217.50
Telephoning	.40
Transportation	5.53
Balance, February 11, 1908	119.36
	\$2,203.06

Having this day examined the books and accounts of the Treasurer, we hereby certify that they are correct, and that the balance in the bank agrees with the same.

HENRY J. KELLOGG,

F. J. EASTERBROOK,

Auditing Committee of the Board of Direction.

It was voted that the report be accepted and printed in the proceedings.

The report of the special committee, appointed at the last meeting to consider the subject of "The Obligation of Engineers to Contractors," was read by the Secretary as follows:

To the President and Members of the Connecticut Society of Civil Engineers:

GENTLEMEN:—Your committee, appointed at the last annual meeting to take under consideration the subject "The Obligation of the Engineer to the Contractor, taken in connection with his obligation to his employer, not only as regards the drawing up of contracts, but also as regards the equitable interpretation of the same," have carefully considered the matter, and beg leave to report.

It does not seem to be within the province of this Society to lay down or to formulate any set of rules or regulations which should be applied, as the conditions are so varying and there are, so often, certain conditions which can apply only to individual cases.

The engineer, we must all agree, holds a peculiar position between the owner, or employer, and the contractor.

It is seldom that the engineer has anything to say as to who shall receive a contract as, if he has prepared the specifications, they must be gotten up in an entirely impersonal manner, and must allow of such interpretation that whoever the contractor may be, the employer may be assured of obtaining just what he wants and just what he expects.

The engineer is placed in charge of the work to see that it is carried out in a manner that shall be without hardship or unreasonableness to either party, and he is supposed to act strictly as a disinterested person. While he must maintain the rights of his employer, he must understand, also,

that the contractor has certain rights which must be considered, and that a contract is a mutual agreement. The engineer does not hold his position simply to inflict penalties or undue requirements upon the contractor.

To sum it all up in a few words, the relations between the engineer, the contractor and the employer should be such, that without discrimination or unfairness a piece of work should be performed in a manner that is a reasonable interpretation of the specifications or contract, bearing in mind that all men have rights and that it is up to the engineer to consider all matters fairly.

Signed,

CHAS. F. CHASE,

C. H. BUNCE.

CHARLES A. FERRY,

Committee.

It was voted the report be accepted and printed in the proceedings.

THE PRESIDENT: The Secretary informs me that there is another special committee to report at this time.

MR. C. E. NICHOLS: Mr. President, there was a committee appointed to consider as to the advisability of fixing minimum charges to be made by engineers. That committee has not been able to get together at any one time. This morning we had a short meeting and we thought it best to report to this meeting that it was the best policy for the Society not to attempt any action on the question of fixing rates, that it was a matter which had better come before the engineers themselves in private practice, and was not one for the Society itself to take any action upon. We think it is a question which would open a wide discussion, and while perhaps there ought to be something done to secure better compensation for engineers, it was not thought best for the Society as a whole to take action. That is the recommendation that we make.

MR. KELLOGG: Would it not be well to continue the committee for another year? They have done well enough. It is a matter of some importance and they might care to think it over further.

MR. BURT: Mr. President, as Mr. Nichols has stated in his report, it seems as if the members of the committee had deemed it unwise to do anything in reference to improving the compensation of engineers. The committee realized that the profession, as a profession, is very poorly compensated in a great many ways for the services of its members, but they also felt that in the matter of the duties of engineers, that they come up in such complicated forms, and arise in such a variety of ways in the engineering business, that it is practically impracticable and impossible to stipulate or fix any certain sum for certain work. A minimum charge per diem for the engineer and his assistant, ordinarily two, on a small piece of work, might be fixed, but at the same time the committee have realized that oftentimes, even for those men, there were conditions and circumstances which might change the whole situation, and it did not seem wise, from a practical standpoint, to recommend that a minimum charge should be fixed, or that a per diem should be specified. I am speaking

now of the ordinary run of work outside of a city or town, with a minimum charge for a man and two competent assistants. Some of the members of the committee thought that might be a wise move. The committee, however, is not unanimous in that respect. But, at any rate, what the masters of the profession received in the way of compensation was something that was a practical matter, and it seemed to some of us, that it was a matter proper to come up in discussion before this meeting, and I would like very much to hear an expression from those who have had occasion to look into the same problem. There is a tendency, as we all know, to get work in a great many cases, not all, where the character of the service is more appreciated than the exact charge. In a large sense, in these commercial times, it seems that the matter of charge is certainly one that has given occasion for criticism. It seems to me that really the only basis of a fair charge was the character of the work, the importance of it, and on the basis of what in that particular case would be fair compensation. In a matter of great importance there should be a very much larger remuneration than in matters of ordinary character. We all realize that there are a hundred and one things that come into a professional man's life that go to make up his compensation, and that they are all needed to fill out. Most of the profession are equipped in such a way, especially in city departments, to accept the character of the work which will come in. It is not the exact time that a man takes to do a particular class of work, but it is his readiness to do it, and the expense that goes with it to keep up his office. I am speaking especially of the expense of keeping up an office to the standard that is able to take care of any line of work which ordinarily comes into the business life of an engineer. That is a principle of importance that is recognized in all lines of professional work. Only the other day I had occasion to consult a surety company who had a large trust to carry out in the way of a settlement of an estate, and the company's representative said to me, that the charges were not based on the clerical work but on the responsibility that is imposed upon us, and it seemed to me that that was a very wise and proper position to take. For instance in the line of state highway business there are matters that require cool judgment and a high grade of engineering talent. I think I am safe in making the statement that in some of the highway work the construction is up to the standard which would be required in high grade railroad or bridge construction. There is work which goes largely to the specialist, but in the layout and in the permanent construction of roads and bridges, it should certainly be recognized that it requires a high grade of skill in the workman, and that the grade of skill required for the work should have its proper compensation according to the standard I have mentioned. In most of our large works of importance, the rates are fixed upon some foundation which represents the aggregate of ideas of a great many persons. It is not necessary in all cases, but in a great many, and I consider it so in the matter of state work, that the engineer should be a permanent factor in it, and, as it is responsible work, that he should be compensated in proportion. I must say from what I have heard from

some parties, and from my own experience, that this is not the case. The condition many times is that the matter is handled in such a way as to cause the engineer to come out of the little end of the horn.

I should hardly want to take the position of advocating the same methods that some of the trades have sprung upon the public, but at the same time we cannot help but recognize that there is strength in union, and what has been gained in a great many cases has been gained by the union of workingmen. We see that illustrated in everyday life. There are a good many phases of this question and it is one which I think could be very profitably discussed. It would be, I know, a great satisfaction to the members of the committee to hear an expression from the other members of the Society in regard to it, if it would not take too much time.

MR. HILL: Mr. President, I will merely take the time to say a word, and that is with reference to the action of the Society on this subject. I quite agree with Brother Burt in what he says as to some phases of the subject, but it seems to me an entirely wrong conclusion for the Society to attempt to dictate to each member what they shall charge for such and such services. I think that is a matter that ought to be left entirely to the judgment of each member. I think it is an entirely wrong principle to attempt that. I hope that the Society will not do so. Take, for instance, the American Society of Engineers, which is one of the strongest societies in this country, if not in the world, and they have no such regulation. I have had experience on the matter for several years, and I am absolutely certain that the Board of Direction of the American Society would not tolerate for a moment any such principle as the right of the Society to dictate to the members what they shall charge for personal services. I hope that the matter will be left just where it is.

MR. PARSONS: Mr. President, I wish to say in regard to that, that I agree with what Mr. Hill has just stated, so far as taking any decided stand by the Society is concerned, but there is one point in regard to this discussion that I think the engineers ought to consider, and that is with reference to this state highway business. I know in a case recently where some highway work was being done that the engineer in charge was only allowed by the commissioner the sum of six dollars a day for his services, including, of course, the use of instruments, etc. Now that sum seemed to me decidedly small compensation for an engineer in charge of a state road. The commissioner's plea was that no other engineer in the state had sent in a bill for over that amount, which had been allowed. It seems as though our state ought to be willing to pay fair compensation for the services of a competent engineer in charge of such work. I do not know as there is anything to be said regarding the position that the Society ought to take, as to whether there should be a fixed charge or not, but it seems to me that the least price that a man ought to accept for that kind of work would be ten dollars a day.

MR. NICHOLS: I have had some talk with engineers in New Jersey. They have a combination formed by fixing a scale, but there it is done

between themselves, and not through the Society. The engineers in private practice have agreed among themselves as to the rates. They tell me that they have been living up to the agreement, and that it works very satisfactorily. I think the same course can be taken here, and that the matter is one that should be left out of the Society altogether.

After some further discussion it was voted, the report of the committee be accepted, and the committee discharged with the thanks of the Society.

The following were elected to membership in the Society: Jonathan H. Child of Wallingford; Matthias W. Denman of Springfield, Mass.; Charles A. Sibley of St. Louis, Mo.; Charles P. Waterman of Bristol, Conn.; E. C. Webster of New Haven, Conn.

ADDRESS OF PRESIDENT DANIEL S. BRINSMADE.

Having been fortunate enough to have been present at the birth of this institution, which next year will be entitled to celebrate its twenty-fifth anniversary, I may perhaps be permitted to indulge in a little retrospection.

During the first year of the life of this Society five honorary and thirty-eight active members were admitted.

Considering the restricted field from which a membership could be recruited in 1884, I think this was a good showing, and we can but admire the courage and enthusiasm with which this advance guard pursued this work, holding the first year four meetings with an average attendance of over sixty per cent. of the membership. Thirteen of the members joining the first year are still upon our rolls. I think it is quite remarkable that such a large number of the originators of the Society should have remained faithful to its interests for nearly a quarter of a century. That they planned even better than they expected or even hoped is demonstrated by the success and influence to which this Society has attained, our membership having increased over sevenfold.

Of the choice vintage of 1884, so happily alluded to by one of our ex-Presidents in introducing a member who joined the Society at its beginning, nine have been honored by filling the President's office of this Society. The enthusiastic interest shown in 1884 seems to have continued during the early days of this Society, for in 1890 the membership had grown to eighty, and the President's report of that year indicated a great variety of work done in the state under the supervision of the Society members. During the business depression the following three years and continuing for some years thereafter little gain was made in membership, but commencing in 1900, perhaps partly due to the general prosperity of the country but probably largely due to the broader field opened for engineering, the membership rapidly increased until at the present time we have 284 members. But it is not alone in membership the Society has shown prosperity; its publications have increased in

interest and in the number of subjects treated. The volume last published contained over two hundred pages composed of interesting papers, finely illustrated, and is a work of which the Society may well be proud.

The summer meeting the last year began in New Haven and ended in New Haven, as many other good things have done. However, in swinging around the circle the members had an opportunity to visit other places, although perhaps lesser lights than Connecticut's Hub.

The party were conveyed by trolley via Derby and Waterbury, affording the members fine opportunity to view both the electrical and steam road improvements being made along the Naugatuck Valley. The Naugatuck River was at a low stage and when we were once on the track there was no danger of losing the scent. However, when we arrived at the Club House in Waterbury no one seemed to have lost his appetite. After partaking of a light lunch, the members were given the freedom of the city for about two hours, giving them a fine opportunity to visit the sites of the railroad improvements in progress and the sewage disposal plant. A beautiful ride over the Cheshire hills and the party were landed at the Cheshire Inn.

There are certain days in the history of every institution which ever after are referred to as red letter days. I think for a long time the members of the Connecticut Society, who were privileged to witness or participate in the ball game played on the grounds belonging to the Cheshire Inn and partake later of the dinner served, will look back to this occasion with great pleasure.

Just as the sun was sinking in the western horizon, casting a glow of beauty over the Cheshire hills, we took the trolley for New Haven, where, thanks to our good pilot, to whom we were so largely indebted for much of our day's pleasure, we arrived safely. Who shall say that the day was not well spent?

Early in January of the present year I sent out circulars to members of the Society residing in the state, inquiring for information as to the class, amount of work and its cost, done during the past year under their supervision. I did not expect to obtain information which would be of special use to our members as a basis of estimate for cost of work, but I did hope to obtain a fairly accurate cost of the work done under their supervision during the year, not only as a matter of interest but especially to show the great responsibility placed upon the members of the engineering profession. I received over thirty replies to the circulars sent out, which being collated show the following results:

For Sewer Work	\$ 244,193.28
Water Works Construction	311,285.18
Electric Roads	176,520.00
Paving	268,633.53
Bridges	1,629,271.62
all other purposes	1,810,221.81
Making a total of	\$4,440,125.42

Although a very large amount of steam road construction has been under the supervision of our members, the returns of the cost of this branch of engineering were so incomplete that I have not included them in the above estimates, but a conservative estimate, I am sure, would add sufficient to the above amount to make over \$6,000,000.00 of work that has been done under the direction of members of the Society residing in the State of Connecticut. These figures are by no means the full measure of the responsibility assumed; they represent in a general way the approximate cost of the enterprises that have been executed, but they do not include the value to be placed upon the trained judgment in passing upon enterprises which do not and should not materialize, nor do they include the value to be placed upon the administrative talent now so often required from members of the engineering profession which is needed in the superintending and conducting of so many of our transportation and industrial corporations.

Three years ago the retiring President said: "With the layman, the standing of the engineer as compared with other professions is not on the plane it should be." I believe this condition still exists, and that it is the duty of each and every one of us to do all in his power to place it upon its proper plane.

At our last annual meeting a proposed bill to regulate the practice of civil engineers and surveyors in Connecticut was discussed. I have a feeling that the proposition was handicapped at the start by my own well-meant but perhaps unfortunate efforts to place the measure in such a position before the Legislature that action could be taken if the Society favored it.

I believe a law passed by the Legislature along the line suggested in the bill discussed last year will help to raise the standard of the engineering profession and I hope in the near future this matter will be more thoroughly investigated by the membership. In the meantime, let each one of us do his best to accomplish the same result.

Due to the increased demand for water supply in the growing cities and towns throughout the state, and the incentive given to water power development, due to the extensive application of electricity to long distance transmission, the matter of stream measurement is becoming of vital importance. The United States Government is doing some work along this line, but I am informed that at the last session of Congress the appropriation for carrying out the work was reduced. I would like to suggest the appointment of a committee to have this matter in charge and if the question of appropriation is again considered by the Government, that action may be taken to convince them of the necessity of pursuing the work and increasing rather than decreasing the appropriation therefor.

We have lost during the year by death the following members: John W. Bacon, Major Powell, Richard Berrian.

For the full report of our membership reference is made to the Secretary's report.

In conclusion I wish to thank the members and my associate officers for their courtesy during the year, and wish the Society a continuation of the prosperity which it has enjoyed in the past.

It was voted to print the President's address in the proceedings.

The President appointed the following Committees on Necrology: In memory of Mr. Powell, Mr. G. E. Verrill, Mr. G. K. Crandall and Mr. W. H. Richards.

In memory of Mr. Berrian, Mr. R. F. Stoddard, Mr. T. B. Ford and Mr. Walter T. Spencer.

The tellers presented the following report of the canvass of the letter ballot for officers for 1908:

VOTE FOR OFFICERS OF THE CONNECTICUT SOCIETY OF CIVIL ENGINEERS.

Total number of votes cast	98
Necessary for a choice	50
For President, Edw. W. Bush	98
For First Vice President, F. J. Easterbrook	94
A. H. Terry	1
S. B. Palmer	1
For Second Vice President, Fred J. Oldershaw	83
S. B. Palmer	1
For Secretary and Treasurer, J. Fred. Jackson	97
Edw. E. Minor	1
For Board of Direction, J. K. Punderford	92
George K. Crandall	91
A. Wm. Sperry	1
Clarence Blakeslee	1
C. E. Chandler	1

THE PRESIDENT: I declare that these names which have been read by the committee are appointed as the officers-elect of this association for the ensuing year. I think we have with us our new President, Mr. Bush, and I am sure that we would all be very happy to hear from him.

MR. BUSH: Mr. President and Gentlemen of the Connecticut Society, I thank you very much for the honor. I shall not occupy much of your time. I will only recall the closing remark of our President, in which he said that he hoped for the continued success of the Society, and I, too, in this position to which I have been newly elected, think I can hope a little bit harder for the same result. I hope that the members will continue their interest in the Society, and will give it their hearty support, not only in the matter of preparing papers, but in the discussions, and taking an interest in the Society. We have a membership now of about 275, which, I think, is very fairly representative of the engineers of the state. It certainly should be with a membership of that size. It will be my sincere endeavor to further the interests of the Society and I ask for your support. (Applause.)

THE PRESIDENT: I think that closes the regular business.

If there is any miscellaneous business to be presented there is now an opportunity.

MR. HILL: The President made a suggestion about the appointment of a committee on water supplies, or rather in reference to a committee upon

the measurement of the run-off of streams. Mr. Ferry, the other day, made a suggestion which I think is worthy of consideration in this connection, and that is, that the committee should be appointed to see if legislation could not be obtained for this state similar to the legislation in Massachusetts in regard to the appropriation of water supplies. In this state, as the law now stands, the company proposing to take water supply must pay for all the water of that shed, whereas in Massachusetts they can designate the amount that they wish to take for that purpose, and later on if they wish to take more they can have another appraisal of the portion which they wish to take in addition. Now it frequently happens that water companies only desire to take a small portion of the run-off of a particular shed, but under the present law they have to pay for it all.

I would like very much to hear some discussion as to the desirability of appointing a committee to take that matter up.

THE PRESIDENT: Gentlemen, you hear the remarks of Mr. Hill. Will you make any motion?

MR. HILL: In order to bring the matter properly before the Society, Mr. President, I will move that the committee to be appointed also take into consideration the question of securing legislation in regard to the appropriation of water supplies in this state.

I have written the motion out, Mr. President, and the way it now reads is as follows: I move that the recommendation of the President for the appointment of a committee on the measurement of streams be adopted and that the committee also take into consideration the enactment of legislation relating to the appropriation of water for public supplies on the lines of the Massachusetts law.

THE PRESIDENT: Gentlemen, you hear the motion. What is your pleasure to do with it?

MR. NICHOLS: I think the number of men on the committee should be named, should it not? It seems to me that that should be fixed.

MR. HILL: There seems to be difference of opinion as to that. I suggested that the number be five. Possibly it may be well to get the sense of the Society.

THE PRESIDENT: We can do that after we get the committee appointed.

MR. NICHOLS: I think the number should be fixed in the first motion. My idea of it is that there should be at least one from each county.

THE PRESIDENT: Is the motion of Mr. Hill's seconded?

Motion seconded.

THE PRESIDENT: Will you remark further upon the motion?

MR. BUSH: Mr. President, does this motion authorize this committee to introduce the bill into the Legislature to that effect? If not, it seems to me that we ought to consider that phase of it. We will not have our annual meeting again until after the time has passed for bills to be introduced into the Legislature. It seems to me if this committee considers this subject favorably they ought to get somebody to introduce a bill, or they should be authorized to do it, or we ought to authorize them at this meeting or else we will be up against it.

MR. HILL: I intended to word the motion so as to cover that point; that the committee take such action in regard to that as they deemed advis-

able. That should be included. Perhaps I did not express it clearly enough.

THE PRESIDENT: If it is understood I think it is all right. Will you remark upon the motion further? If not I will put it to the vote.

Motion carried.

Now will you take up the matter of how many members this committee shall be composed of and how it shall be appointed.

MR. FERRY: I move that the committee consist of five members and be appointed by the chair.

Motion seconded.

MR. HILL: I will move to amend that, so that the chair shall be one of the committee.

MR. FERRY: I will accept the amendment.

THE PRESIDENT: It is moved and seconded that the committee of five be appointed, of which the chair shall be a member. Will you remark upon the motion?

Motion carried.

It was voted that the Secretary edit the proceedings of the meeting so as to give an outline of all the business done.

Voted to adjourn until 3 P. M.

During the intermission the visiting members were entertained at lunch at Heublein's by the New Haven members, and at 2 P. M. were conducted through the Hammond Laboratory, where the different departments were very interestingly explained by Prof. Huntoon.

MORNING SESSION—WEDNESDAY, FEBRUARY 12, 1908.

Convention called to order at 10:10 A. M. President Brinsmade in the chair.

Mr. C. H. Chandler not being present, his paper on "Stream Flow Data" was read by Mr. S. B. Palmer. The paper is printed on page 37.

Mr. Ermon E. Peck of Hartford, being absent, his paper on "Water Waste Investigations" was read by Mr. R. M. Clark.

The paper is printed on page 67.

Mr. M. W. Denman read his paper on "Reinforced Concrete Bridges."

The paper is printed on page 72.

Mr. J. Frederick Jackson then read his paper on "The Harbor and Rivers of New Haven."

The paper is printed on page 94.

Mr. Walter S. Morton of New York read his paper on "Hydraulic Fill Dams."

Mr. Morton's paper is printed on page 106.

Mr. Edward E. Minor of New Haven then read his paper on "The Mill Rock Water Tower."

Mr. Minor's paper is printed on page 115.

Votes of thanks were extended to The Governing Board of the Sheffield Scientific School, the members of the local committee of arrangements and to the members who presented papers. Mr. Wm. B. Fuller was elected an honorary member of the Society. The meeting was adjourned, subject to call.

CONSTITUTION.

ARTICLE I.

NAME AND OBJECT.

SECTION 1.—The name of this Society shall be the CONNECTICUT SOCIETY OF CIVIL ENGINEERS.

OBJECT.

SEC. 2.—The object of this Society shall be the professional improvement of its members; the encouragement of social intercourse among men of practical science, and the advancement of engineering in its several branches, to wit: Civil, hydraulic, naval, sanitary, mechanical, electrical, architectural, mining, geological, metallurgical, and chemical; the reading and discussion of papers, or to hear lectures on any of the above topics relating to engineering science, and the transaction of all business properly belonging to said Society.

ARTICLE II.

MEMBERSHIP.

SECTION 1.—The membership of this Society shall consist of Members, Honorary Members and Associate Members.

MEMBERS.

SEC. 2.—Members must be at least twenty-one years of age and have had two years' actual experience in some branch of engineering or surveying, or shall have been graduated from an engineering course in a college or university of recognized standing, and they only shall be entitled to vote or transact business for the Society.

HONORARY MEMBERS.

SEC. 3.—Honorary Members may be as many as the Society shall elect. They shall have no vote, nor shall they be eligible to hold office. They shall have the right to attend all public meetings and to enjoy such other privileges as the Society may see fit to grant, excepting, however, such Honorary Members as may be elected from *active membership*, when they shall retain their right to vote and to hold office.

ASSOCIATE MEMBERS.

SEC. 4.—Any person desiring to become associated with this Society, who is not eligible to active membership, may make application, and if said application receives a favorable report from the Board of Direction, it shall be acted upon by the Society at the next regular meeting, and if said candidate shall receive a majority of the votes cast he shall be declared elected as an Associate Member. Associate Members shall have no vote, nor shall they be eligible for any office.

ARTICLE III.

OFFICERS AND THEIR DUTIES.

OFFICERS.

SECTION 1.—The officers of this Society shall be, a President, two Vice Presidents, a Secretary and Treasurer, an Assistant Secretary, and four Directors.

ELECTION OF OFFICERS.

SEC. 2.—The officers, excepting the Assistant Secretary, shall be elected at the annual meeting, and shall hold their respective offices until the final adjournment of the meeting in which others are elected and qualified in their places.

PRESIDENT.

SEC. 3.—The President shall preside at all meetings when present. He shall be chairman of the Board of Direction, and of all standing committees, and shall appoint all special committees, unless otherwise ordered by a vote of the Society.

VICE PRESIDENTS.

SEC. 4.—In the absence or inability of the President to act, the Senior Vice President present shall perform his duties.

SECRETARY.

SEC. 5.—The Secretary shall attend all meetings of the Society, and the Board of Direction, and shall keep the minutes thereof. He shall conduct the general correspondence of the Society, receive communications addressed thereto, and present the same to the proper committees, officers, or meetings. He shall issue notices of all meetings, inform committees of their appointment, and officers and new members of their election. He shall notify all committees of coming meetings and prepare the matters for presentation. He shall keep a complete list of all members, with their addresses and dates of election. He shall publish the annual report. He shall perform such other duties pertaining to his office as may be imposed upon him by the Society or by the Board of Direction, and shall receive a salary to be fixed by the Society.

TREASURER.

SEC. 6.—The Treasurer shall keep the accounts, collect all the funds of the Society and shall deposit the same to the credit of the Society in such depository as may be designated by the Board of Direction. He shall pay all bills, when approved by the President or a majority of the Board of Direction. He shall keep book accounts of his receipts and expenditures, which shall at all times be open to the inspection of the Board. He shall make a duly audited itemized report to the annual meeting. He shall give bonds for the faithful performance of his

duties, in such amounts and with such sureties as the Board of Direction may require, and he shall receive such remuneration as the Society may vote to him from time to time. The Board of Direction shall audit the Treasurer's accounts and books annually.

ASSISTANT SECRETARY.

SEC. 7.—The Assistant Secretary shall be appointed annually by the President, and his duties shall be such as would pertain to the office of executive secretary.

BOARD OF DIRECTION.

SEC. 8.—This Board shall consist of the President, the two Vice Presidents, and the four Directors. It shall have supervision and care of all the affairs and property of the Society, and shall conduct the same in accordance with the Constitution and By-Laws. The President or one of the Vice Presidents shall preside at all meetings of the Board, in the order of seniority. In the absence of all these officers, a chairman *pro tem.* may be appointed for the meeting. The first year after this section is adopted, four members shall be chosen at the annual meeting, two shall be chosen for a term of one year and two to serve two years. At all subsequent annual meetings two members shall be chosen to serve two years. Four members shall constitute a quorum to transact business.

ARTICLE IV.

ELECTIONS.

OFFICERS, WHEN ELECTED.

SECTION 1.—At each annual meeting the Society shall elect by ballot, a President, two Vice Presidents, and a Secretary and Treasurer, to serve one year; also two Directors to serve two years.

NOMINATIONS, HOW MADE.

SEC. 2.—A nominating blank, containing a list of officers to be voted for, shall be sent by the Secretary to each member, at least sixty (60) days before the day of the annual meeting. The nominations for officers shall be returned to the Secretary in an envelope endorsed with the member's signature, within twenty-one (21) days from the date upon which the blanks were mailed to members, and shall be delivered by him, unopened, to the Board of Direction at a meeting to be held by them to canvass such nominations.

A member nominated for an office by as many as ten (10) other members may become a candidate for that office. If a member be nominated for more than one office, he shall be considered as having been nominated for that office for which he received the most nominating ballots.

If no member receives ten (10) nominating ballots for an office, or if for any reason there should be no candidate for an office, the Board of Direction shall nominate at least two candidates for that office.

All nominees for office shall be notified at once by the Secretary of their nomination and, unless the Secretary receives a prompt declination, it shall be assumed that they have accepted such nomination.

ELECTIONS, HOW CONDUCTED.

SEC. 3.—At least twenty-one (21) days before the annual meeting the Secretary shall send each member a ballot, containing the names (arranged alphabetically) of the candidates for each office. This shall be accompanied by an envelope addressed to the Secretary, with a blank space on the back for the signature of the member voting, also a blank envelope carrying no mark for recognition.

Each member shall signify his choice of candidates on the ballot and return it to the Secretary in two sealed envelopes; the inner one to be left entirely blank, and the outer one endorsed with signature of sender.

Ballots may be sent by mail to the Secretary or handed to him directly. The Secretary shall deliver the ballots, unopened, to the tellers appointed by the presiding officer.

The polls will close at eleven o'clock in the morning of the day of the regular annual business meeting of the Society.

MEMBERS IN ARREARS CANNOT VOTE.

SEC. 4.—It shall be the duty of the Treasurer to furnish the tellers with an alphabetical list of members in arrears for dues for two years or more, and no vote from a member so in arrears shall be counted. Ballots received from such members shall be returned to them unopened with a statement of the reason for such action.

PLURALITY ELECTS.

SEC. 5.—The candidate for each office receiving a plurality of the votes shall be declared elected. In case of a tie vote, the meeting shall proceed to vote by ballot for the candidates who are tied.

NOTIFICATION.

SEC. 6.—The Secretary shall officially notify in writing each officer of his election.

Officers so elected shall qualify and assume their duties immediately after the adjournment of the meeting at which they are elected, and shall hold office until their successors are duly elected and qualified.

VACANCIES.

SEC. 7.—Vacancies occurring for any cause in the list of officers shall be filled by the Board of Direction.

ELECTION OF MEMBERS.

SEC. 8.—Each application shall be announced on the notices for the next meeting after it is received, shall then be considered by the Board of Direction, and, if approved, shall be presented to the Society for

ballot at a regular meeting. If a candidate receives a majority of the ballots, he shall be declared elected. In case of rejection, no minute shall be published, but the Secretary shall notify the applicant by letter.

APPLICATION FOR MEMBERSHIP

SEC. 1.—All applications for membership or for transfer from one grade of membership to another, shall be made on a regular form to be secured from the Secretary, and to be endorsed by three Members. This form shall contain immediately over the signature of the applicant a clause in which the applicant shall agree that if elected he will be governed in all Society matters by the Constitution and By-Laws, and will forward the interest of the Society at all times.

ARTICLE V

MEETINGS

ANNUAL MEETING

SECTION 1.—There shall be a regular annual meeting held on the second Tuesday of February each year, at such place as may be selected by the Board of Directors, of which due notice shall be given by the Secretary.

MEETINGS, HOW CALLED

SEC. 2.—Special meetings may be called by the President and, when so called, notice of the meeting specifying the business thereof shall be mailed by the Secretary to the postoffice address of each member at least ten days before such meeting shall be held. Special meetings shall be called by the President on written application of any ten to members.

QUORUM

SEC. 3.—Ten per cent of the membership shall constitute a quorum for the transaction of ordinary business, except for the election of officers or for voting on amendments to the Constitution or By-Laws, which shall require fifteen per cent.

ARTICLE VI

DUES

SECTION 1.—The annual dues of Members and Associate Members shall be three \$3.00 dollars per year, payable in advance at the annual meeting.

Members elected at any time of the year shall pay full dues for that year.

SEC. 2.—Honorary Members shall pay no annual dues.

SEC. 3.—The Board of Direction shall have power to remit dues when, in their opinion, it is for the best interest of the Society.

ARTICLE VII.

DEPRIVATION OF MEMBERSHIP.

SECTION 1.—Any member whose dues shall remain unpaid for two (2) years shall be notified by the Treasurer, by sending by registered mail a bill for dues in arrears, on the face of which bill shall be printed the sections of the Constitution covering such cases. If the dues are not paid within thirty (30) days after such notification, the matter shall be presented to the Board of Direction, who shall have power to drop such member from the roll.

RESIGNATIONS.

SEC. 2.—Resignations must be submitted in writing to the Secretary, and may be accepted by the Board of Direction when all indebtedness to the Society has been discharged.

SEC. 3.—All charges against any member shall be investigated by the Board of Direction before being submitted to the Society.

Any member may be expelled for conduct which may be deemed prejudicial to the Society, by a two-thirds vote of the Members present at a business meeting; provided, that not less than fifteen (15) vote for expulsion, and that such member shall have had one month's notice of the charges preferred against him and of the time appointed for their consideration. All charges must fully set forth the offense or offenses alleged, and must be signed by the members preferring them. An attested copy must be furnished the accused, who shall be entitled to be present and to be heard in defense, in person or by attorney, at all meetings at which the charges are investigated, except during the time when a final vote is being taken.

ARTICLE VIII.

AMENDMENTS TO THE CONSTITUTION.

SECTION 1.—Proposed amendments to this Constitution must be presented in writing at a regular business meeting of the Society, and signed by at least three Members.

Amendments so presented shall be read at the meeting and a copy filed with the Secretary at the same time. At the meeting when presented the proposed amendments may be discussed and amended, but cannot be adopted.

SEC. 2.—At any regular business meeting the amendments previously proposed, according to Section 1, may be voted upon by letter ballot. These ballots shall be sent out with the call for the meeting and shall have the proposed amendment, together with the section of the present Constitution covering the point in question, printed upon the ballot. With the ballot shall also be sent an envelope directed to the Secretary and marked "Ballot on Amendment." The Secretary shall keep these letters unopened and present to the presiding officer all replies received

up to the hour of closing the polls. Tellers shall be appointed by the presiding officer, who shall open and count all ballots. The result shall be announced at the meeting by the presiding officer. Two-thirds of the ballots cast will be necessary for the adoption of an amendment.

SEC. 3.—The Board of Direction is authorized to number the Articles and Sections of the Constitution and By-Laws to correspond with any changes that may be made.

BY-LAWS.

MEETINGS.

1. In addition to the regular annual meeting, as provided by the Constitution, the Society shall hold at least one other general meeting, and may hold such other meetings to listen to lectures or addresses, or to visit engineering works of interest, or of a purely social nature, as the Board of Direction may decide to call.

GENERAL ORDER OF BUSINESS AT ANNUAL MEETING.

2. The following general order of business shall be observed at annual meetings:

1. Presentation of, and action upon, minutes of last meeting.
2. Report of Board of Direction.
3. Report of Secretary.
4. Report of Treasurer.
5. Report of any Special Committees.
6. Election of new members.
7. Election of officers.
8. Address of President.
9. Miscellaneous business.
10. Papers, lectures, or addresses.
11. Adjournment.

BUSINESS MEETINGS—ORDER.

3. The following general order shall be observed at Business Meetings:

1. Presentation of, and action upon, minutes of last meeting.
2. Miscellaneous announcements.
3. Stated business.
4. Adjournment.

4. Contributing Members under the old Constitution shall become Associate Members upon the adoption of the Revised Constitution.

5. Actual personal transportation expenses incurred by the Secretary in attending meetings shall be paid from the Society treasury, upon approval of the President or two members of the Board of Direction.

6. In the election of Honorary Members, a unanimous vote is necessary to elect.

7. The Society may at any time, duly named for the purpose, enact By-Laws for the future guidance, consonant with the Constitution. These By-Laws may be amended or repealed at any meeting, in the call for which meeting a copy of the proposed amendment or addition shall have been printed and sent to each member with the said notice.

PARLIAMENTARY RULES.

8. In all questions arising at any meeting, involving parliamentary rules, not provided for in these By-Laws, Roberts' Rules of Order shall be the governing authority.

VISITORS.

9. Visitors may be admitted to meetings under such rules as the meeting may prescribe.

10. All forms, such as blanks for application for membership, ballots for officers, ballots on amendments to Constitution or By-Laws, and other necessary blanks for the conduct of the business of the Society, shall be prepared by the Secretary and approved by the Board of Direction.

List of Members.

With Addresses and Dates of Election.

Members are particularly requested to inform the Secretary at once of any change in address.

HONORARY MEMBERS.

CHITTENDEN, PROF. RUSSELL H.	April 20, 1901
Dean of Sheffield Scientific School of Yale University, New Haven, Conn.	
CLARK, EDGAR	June, 1887
Putnam, Conn.	
CLARK, JOHN E.	April, 1884
Prof. Mathematics, Emeritus, at Sheffield Scientific School, Yale University, South Terrace, Longmeadow, Mass.	
FITZGERALD, DESMOND	Jan. 8, 1901
Consulting Engineer, Brookline, Mass.	
FROST, GEORGE H.	April, 1884
President Engineering News Publishing Co., New York.	
FULLER, WILLIAM B.	Feb. 12, 1908
Consulting Engineer, New York.	
HADLEY, DR. ARTHUR T.	April 20, 1901
President Yale University, New Haven, Conn.	
HAUPT, LEWIS	Feb. 12, 1907
Consulting Engineer, Philadelphia, Pa.	
HAYNES, EDWARD C.	Jan. 14, 1890
Ware, Mass.	
PETTEE, WILLIAM E.	Jan. 10, 1899
Civil Engineer, Salisbury, Conn.	
SEYMOUR, WILLIAM O.	Feb. 9, 1904
Railroad Commissioner, Ridgefield, Conn.	
SKINNER, FRANK W.	Jan. 9, 1900
Editorial Staff of the Engineering Record, New York.	
SCOFIELD, HORACE G.	Feb. 14, 1906
Civil Engineer, Bridgeport, Conn.	

MEMBERS.

ALDERSON, ALGERNON B.	Jan. 10, 1899
Town Engineer, West Hartford, Conn.	
AMRHYN, GUSTAVE X.	Feb. 9, 1904
Associate Member, Department of Parks, New Haven, Conn.	
AUGUR, EDWIN P.	April, 1884
Civil Engineer and Surveyor, and City Surveyor, Middletown, Conn.	

AYRES, HENRY W.	Jan. 13, 1885
Hydraulic Engineer, Hartford, Conn.	
AZHDERIAN, REUBEN B.	Feb. 12, 1907
Civil Engineer, Bridgeport, Conn.	
BACON, ARTHUR W.	Feb. 9, 1904
Civil Engineer, New Britain, Conn.	
BANTA, D. SCHUYLER	Aug. 23, 1905
Civil Engineer, Hartford, Conn.	
BARKER, WILLIAM H.	Aug. 10, 1904
Jenkins & Barker, Hartford, Conn.	
BARNEY, SAMUEL E.	Jan. 9, 1900
Prof. Civil Engineering Sheffield Scientific School, Yale University, New Haven, Conn.	
BEACH, CHARLES EDWARD	Jan. 10, 1893
Civil Engineer, West Hartford, Conn.	
BELDEN, CLIFFORD H.	March 30, 1900
Civil Engineer, Hartford, Conn.	
BELDEN, EDGAR T.	Jan. 8, 1901
Warner-Miller Co., New Haven, Conn.	
BENNETT, CHAS. J.	Aug. 14, 1906
Engineering Department, N. Y., N. H. & H. R. R. Co., Hartford, Conn.	
BENNETT, RAYMOND F.	March 30, 1900
W. F. Bennett & Son, Contractors, Portland, Maine.	
BIGELOW, HORATIO	Aug. 14, 1907
Civil Engineer, Norwich, Conn.	
BISHOP, GEORGE H.	Jan. 13, 1885
Hydraulic Engineer, Middletown, Conn.	
BISSELL, CLINTON T.	Aug. 10, 1904
Civil Engineer, Brooklyn, N. Y.	
BLACK, WILLIS J.	Feb. 13, 1906
Civil Engineer, N. Y., N. H. & H. R. R., New Haven, Conn.	
BLAIR, CLARENCE M.	Aug. 10, 1904
Civil Engineer, New Haven, Conn.	
BLAKESLEE, CLARENCE	Jan. 9, 1900
Civil Engineer and Contractor, New Haven, Conn.	
BLATCHLEY, WILLIAM J.	Aug. 10, 1904
Civil Engineer, New Haven, Conn.	
BLEIM, DANIEL WILLIAM	Feb. 12, 1907
Manager American Bridge Co., East Berlin, Conn.	
BODFISH, HENRY L.	Feb. 13, 1906
Civil Engineer, N. Y., N. H. & H. R. R. Co., Waterbury, Conn.	
BRADLEY, DANIEL E.	Jan. 9, 1894
President Berlin Construction Co., Berlin, Conn.	
BRETT, THOMAS C.	Aug. 10, 1904
Secretary Yale Safe & Iron Works, New Haven, Conn.	
BREWER, WILLARD SEYMOUR	Feb. 12, 1907
City Engineer's Office, Hartford, Conn.	
BRINSMADE, DANIEL E.	April 20, 1901
Secretary and Assistant Engineer Ousatonic Water Co., Shelton, Conn.	
BRINSMADE, D. S.	April, 1884
Engineer Housatonic Water Power Co., Derby, Conn.	
BROWN, CHARLES B.	Aug. 14, 1907
Civil Engineer, Orono, Maine.	

BROWN, CHARLES O.	Jan. 11, 1898
City Engineer, Danbury, Conn.	
BROWN, EDMUND	Jan. 10, 1899
Superintendent and Engineer of Norfolk Water Co., Norfolk, Conn.	
BROWN, WALTER A.	Oct. 11, 1902
Civil Engineer with J. D. Barker, Springfield, Mass.	
BROWN, WALTER A.	Feb. 13, 1906
Engineering Dep't, N. Y., N. H. & H. R. R., Waterbury, Conn.	
BUCK, HENRY R.	Jan. 10, 1899
Civil Engineer, Hartford, Conn.	
BUDDINGTON, JOHN E.	March 30, 1900
Consulting Engineer and Contractor, New Haven, Conn.	
BUNCE, CHARLES H.	April, 1884
Civil Engineer, Hartford, Conn.	
BURGHARDT, WALLACE	Feb. 13, 1906
Town Engineer, North Canaan, Conn.	
BURT, LUTHER HAROLD	Aug. 14, 1900
Bronx Valley Sewer Commission, White Plains, N. Y.	
BURT, LUTHER W.	Jan. 13, 1885
Civil Engineer and Surveyor, Hartford, Conn.	
BUSCHOR, EMIL CHARLES	Jan. 10, 1899
Civil Engineer and Surveyor, Arlington, N. J.	
BUSH, EDWARD W.	Jan. 10, 1899
Assistant Engineer Conn. River Bridge and Highway District, Hartford, Conn.	
BUSHNELL, W. G.	Feb. 14, 1905
Associate Member, Electrical Engineer, New Haven, Conn.	
CADWELL, WILLIAM H.	May 31, 1893
Civil Engineer, New Britain, Conn.	
CAHN, ALEXANDER	Jan. 9, 1900
Civil Engineer, New Haven, Conn.	
CAIRNS, ROBERT A.	Aug. 29, 1890
Sanitary and Hydraulic Engineer and City Engineer, Waterbury, Conn.	
CARLISLE, HARRY E.	Jan. 9, 1900
Conduit Engineer, S. N. E. Telephone Co., New Haven, Conn.	
CARTER, RALPH B.	Jan. 14, 1890
Civil Engineer, 26 Cortlandt St., New York.	
CAUM, FRANK	Aug. 14, 1900
General Manager Scranton Railway Co., Scranton, Pa.	
CHANDLER, CHARLES E.	April, 1884
Civil Engineer, Norwich, Conn.	
CHAPMAN, FREDERICK S.	Feb. 10, 1903
Civil Engineer, Philippine Islands.	
CHASE, CHARLES F.	March 30, 1900
Engineer Berlin Construction Co., New Britain, Conn.	
CHENEY, RICHARD OTIS, JR.	Jan. 9, 1900
Civil Engineer, South Manchester, Conn.	
CHILD, JONATHAN H.	Feb. 11, 1908
Superintendent of Water Works, Wallingford, Conn.	
CLARK, HERBERT G.	July 18, 1899
Engineer of Keney Park, Hartford, Conn.	
CLARK, ROSCOE N.	July 18, 1899
Assistant City Engineer, Hartford, Conn.	

CLARK, VINCENT B.	Feb. 9, 1904
Civil Engineer, New Haven, Conn.	
CLARK, WILLIAM S.	July 14, 1890
Civil Engineer, Meriden, Conn.	
COE, THEODORE I.	Jan. 9, 1900
Architect, 100 William St., New York.	
COGGESHALL, R. C. P.	June, 1887
Superintendent of Water Works, New Bedford, Mass.	
COLE, CLINTON L.	Feb. 9, 1904
Civil Engineer, Conn. River Bridge & Highway District, Hartford, Conn.	
COLLINS, HARRY C.	July 18, 1899
Berlin Construction Co., Boston, Mass.	
COMSTOCK, LEWIS B.	Aug. 10, 1904
Civil Engineer, New Rochelle, N. Y.	
CORSON, WILLIAM R. C.	Feb. 10, 1903
Electrical Engineer, Hartford, Conn.	
CRANDALL, GEORGE K.	Jan. 11, 1887
City Engineer, New London, Conn.	
CRAWFORD, CHARLES M.	July 18, 1899
Chief Engineer Northern Traction Co., Hamilton, Ohio.	
CRAWFORD, NORMAN McDONALD	July 18, 1899
Consulting Engineer, Cincinnati, Ohio.	
CURTIS, FAYETTE S.	Jan. 9, 1900
Vice President N. Y., N. H. & H. R. R., Boston, Mass.	
CURTISS, GREY WILLIS	Feb. 12, 1907
Civil Engineer, N. Y., N. H. & H. R. R. Co., New Haven, Conn.	
DABOLL, LOREN E.	Jan. 8, 1895
Civil Engineer, New London, Conn.	
DARROW, COURTLAND R.	Jan. 8, 1895
Civil Engineer, Waterford, Conn.	
DAVIS, ARTHUR L.	July 18, 1899
Assistant Manager Eastern District and Export, American Bridge Co., 100 Broadway, New York.	
DAWLEY, EDWIN P.	Aug. 14, 1906
Engineer of Construction N. Y., N. H. & H. R. R., New Haven, Conn.	
DENMAN, MATTHIAS W.	Feb. 11, 1908
With Fred T. Ley, Springfield, Mass.	
DEPEYSTER, FREDERICK	Sept. 3, 1891
General Manager Brainard, Schaler & Hall Quarry, Portland, Conn.	
DEYO, SOLOMON LEF.	Jan. 9, 1900
Chief Engineer New York Rapid Transit Subway Construction Co., New York City, N. Y.	
DuBOIS, AUGUSTUS J.	Jan. 9, 1900
Prof. Civil Engineering Sheffield Scientific School, Yale University, New Haven, Conn.	
DUNCAN, EDGAR T.	Feb. 14, 1905
Civil Engineer, Hartford, Conn.	
DUNHAM, WILLIAM ROBERT, JR.	Feb. 12, 1907
Civil Engineer, Consolidated Railway Co., New Haven, Conn.	
EASTERBROOK, FREDERICK J.	March 30, 1900
Assistant Engineer N. Y., N. H. & H. R. R. Co., New Haven, Conn.	
EDDY, CHARLES W.	Jan. 9, 1900
Assistant Engineer, Waterbury Water Supply, Thomaston, Conn.	

ELLSWORTH, FREDERICK H.	March 30, 1900
Division Engineer, N. Y., N. H. & H. R. R. Co., New Haven, Conn.	
EVERIT, EDW. H.	Oct. 11, 1902
Engineer S. N. E. Telephone Co., New Haven, Conn.	
FARNHAM, CHARLES S.	Feb. 9, 1904
Instructor Civil Engineering Sheffield Scientific School, Yale University, New Haven, Conn.	
FERRY, CHARLES A.	Jan. 9, 1900
Civil Engineer and Surveyor, New Haven, Conn.	
FORD, FREDERICK L.	Jan. 12, 1897
City Engineer, Hartford, Conn.	
FORD, THEODORE B.	April 20, 1901
Civil Engineer, Bridgeport, Conn.	
FULTON, WILL H.	Jan. 8, 1901
City Engineer's Office, New Haven, Conn.	
GAGEL, EDWARD	Jan. 9, 1900
Chief Engineer N. Y., N. H. & H. R. R. Co., New Haven, Conn.	
GILLETTE, GEORGE W. F.	Jan. 9, 1900
G. M. Grant Co., New Haven, Conn.	
GLADDING, HENRY H.	Jan. 9, 1900
Assistant City Engineer, New Haven, Conn.	
GOSS, EDWARD O.	Nov. 29, 1890
Assistant Treasurer Scovil Mfg. Co., Waterbury, Conn.	
GRAVES, EDWIN D.	Oct. 25, 1895
Chief Engineer Conn. River Bridge and Highway District, Hartford, Conn.	
GREENWOOD, ALBERT H.	Feb. 9, 1904
With Berlin Construction Co., Berlin, Conn.	
GREGORY, J. LOUIS	Aug. 10, 1904
Civil Engineer, Larchmont, N. Y.	
HALE, PERRY T. W.	Feb. 10, 1903
Superintendent Middletown Water Works, Middletown, Conn.	
HALL, A. CLARK	Jan. 8, 1901
Hartford Water Department, West Hartford, Conn.	
HALL, CHARLES ERNEST	Feb. 12, 1907
Civil Engineer, Consolidated Railway Co., New Haven, Conn.	
HALL, WILLIAM HENRY	Feb. 12, 1907
Engineering Department, N. Y., N. H. & H. R. R., New Haven, Conn.	
HAND, GEORGE F.	Feb. 13, 1906
Civil Engineer, West Haven, Conn.	
HANS, ALEXANDER JOSEPH	Feb. 12, 1907
Civil Engineer, Locust Valley, L. I.	
HARRISON, IRVING WARREN	Feb. 12, 1907
City Engineer's Office, Waterbury, Conn.	
HARTE, CHARLES R.	Aug. 10, 1904
Civil Engineer, N. Y., N. H. & H. R. R., New Haven, Conn.	
HASTINGS, F. B., Associate Member	Feb. 10, 1903
B. D. Pierce Co., Bridgeport, Conn.	
HATCH, CHARLES	Feb. 13, 1906
Civil Engineer, N. Y., N. H. & H. R. R. Co., New Haven, Conn.	
HAWLEY, ARTHUR S.	Feb. 11, 1902
C. W. Blakeslee & Co., New Haven, Conn.	
HEITMAN, ADRIAN C., JR.	Feb. 10, 1903
Civil Engineer, West Haven, Conn.	

HENDERSON, JOHN T.	July 11, 1898
Assistant Engineer Conn. River Bridge and Highway District, Hartford, Conn.	
HILL, ALBERT B.	Jan. 9, 1900
Civil and Consulting Engineer, New Haven, Conn.	
HINE, FRANK E.	April 22, 1901
Civil Engineer, Fisher's Island, N. Y.	
HOSLEY, ROBERT M.	Aug. 23, 1905
Civil Engineer, N. Y., N. H. & H. R. R. Co., New Haven, Conn.	
HOYT, FRANK N.	July 13, 1899
Civil Engineer, L. E. Myers Co., Chicago, Ill.	
HOYT, SAMUEL N., JR.	Feb. 9, 1904
Civil Engineer, South Norwalk, Conn.	
HUDSON, LOUIS	Aug. 14, 1907
Civil Engineer, New Haven, Conn.	
HULBERT, ROBERT S.	April, 1884
Civil Engineer, Winsted, Conn.	
HULBERT, TIMOTHY ANDREW	Feb. 12, 1907
Engineering Department, American Brass Co., Waterbury, Conn.	
HURLBERT, HINMAN B.	Aug. 14, 1907
Civil Engineer, New Haven, Conn.	
INGERSOLL, C. M., JR.	Jan. 8, 1901
Chief Engineer, Department of Bridges, New York, N. Y.	
JACKSON, J. FREDERICK	Jan. 9, 1900
Assistant Engineer, New Haven, Conn.	
JAMESON, MINOR S.	Feb. 9, 1904
Assistant Engineer, N. Y., N. H. & H. R. R. Co., New Rochelle, N. Y.	
JARVIS, CHARLES M.	April, 1884
Vice President P. & F. Corbin Co., New Britain, Conn.	
JAYNES, FRANK B.	Feb. 10, 1903
Civil Engineer, Bridgeport, Conn.	
JESSUP, JOHN C., JR.	Feb. 9, 1904
Civil Engineer, H. L. Wiley Co., Fort Williams, Ontario.	
JOHNSON, GEORGE R.	Aug. 14, 1906
Civil Engineer, West Haven, Conn.	
JOHNSON, WILLIAM D.	Aug. 14, 1900
Architect, Hartford, Conn.	
JOHNSON, WILLIAM E.	Nov. 29, 1890
Engineer of Hartford Water Works, West Hartford, Conn.	
JONES, WALTER A.	Feb. 10, 1903
Civil Engineer, New Haven, Conn.	
KEENEY, ERNEST A.	Feb. 14, 1905
Civil Engineer, N. Y., N. H. & H. R. R. Co., Lyme, Conn.	
KEHR, HARRY T.	Aug. 10, 1904
Civil Engineer, 330 W. 4th St., New York, N. Y.	
KEITH, HERBERT C.	Jan. 9, 1900
Consulting Engineer, 1213 Morton Bldg., 116 Nassau St., New York City.	
KELLOGG, HENRY J.	April, 1884
First Assistant City Engineer, New Haven, Conn.	
KELLY, CASSIUS W.	Jan. 9, 1900
City Engineer, New Haven, Conn.	
KIRBY, RICHARD S.	March 30, 1900
Instructor in Civil Engineering, Sheffield Scientific School, Yale University, New Haven, Conn.	

KOPCZYNSKI, LEON	Feb. 12, 1907
Civil Engineer, New Haven, Conn.	
LAFORGE, FREDERICK W.	Jan. 13, 1885
U. S. Engineer, Fort Terry, Plum Island, N. Y.	
LANE, JOHN S.	Jan. 8, 1901
John S. Lane & Sons, Meriden, Conn.	
LANE, E. LeROY	Jan. 8, 1901
Contractor, Hingham, Mass.	
LANWETT, HENRY B.	Aug. 14, 1907
Associate Member, Waterbury, Conn.	
LAW, WALTER H.	Aug. 10, 1904
Civil Engineer, Fall River, Mass.	
LAWTON, EDWIN F.	March 30, 1900
Superintendent Hartford Electric Light Co., Hartford, Conn.	
LEACH, SMITH S.	Jan. 8, 1901
Major Engineers, U. S. Government, Washington, D. C.	
LEWIS, ROBERT P.	Oct. 24, 1895
Secretary Blake & Johnson, Waterbury, Conn.	
LIBBEY, JOSEPH H.	Feb. 13, 1906
Assistant Electrical Engineer, N. Y., N. H. & H. R. R., New Haven, Conn.	
LINES, FRANK H.	Aug. 14, 1907
Civil Engineer, New Haven, Conn.	
LOCHRIDGE, ELBERT E.	Aug. 23, 1905
Civil Engineer, Springfield, Mass.	
LUTHER, FLAVEL S., JR.	Feb. 9, 1904
President Trinity College, Hartford, Conn.	
LYNCH, ALEXANDER S.	Aug. 14, 1907
Civil Engineer, West Haven, Conn.	
LYON, C. T.	Feb. 12, 1907
Engineering Department, N. Y., N. H. & H. R. R., New Haven, Conn.	
MAGILL, CLAUDE	Aug. 14, 1907
Civil Engineer, New Haven, Conn.	
MALONEY, DENNIS J.	April 20, 1901
Superintendent of Buildings, Board of Education, New Haven, Conn.	
MALONEY, FRANK A.	Jan. 9, 1900
Assistant City Engineer, New Haven, Conn.	
MANNING, GEORGE E.	Jan. 11, 1898
Civil Engineer, Yantic, Conn.	
MARCHANT, ORSON H.	Feb. 14, 1905
Civil Engineer, New Haven, Conn.	
McKENZIE, J. M.	April, 1884
Civil Engineer and Surveyor, Yalesville, Conn.	
McKENZIE, THEODORE H.	April, 1888
Sanitary and Hydraulic Engineer, Southington, Conn.	
McKENZIE, THOMAS	Feb. 12, 1907
Superintendent of Water Works and Town Engineer, Westerly, R. I.	
McKNIGHT, JOHN T.	May 31, 1893
City Engineer, Rockville. Residence, Ellington, Conn.	
McLEAN, GEORGE H.	Feb. 9, 1904
Civil Engineer, New Haven, Conn.	
MERRELS, CHARLES W.	Jan. 9, 1900
City Engineer's Office, New Haven, Conn.	

MINOR, EDWARD E.	Feb. 9, 1904
Civil Engineer, New Haven, Conn.	
MINOR, JUDSON M.	Feb. 13, 1906
Civil Engineer, Rio Janiero, Brazil, S. A.	
MINOR, SHELDON E.	Sept. 25, 1886
Civil Engineer, Greenwich, Conn.	
MITCHELL, ROBERT E.	Jan. 9, 1900
Civil Engineer and Surveyor, Willimantic, Conn.	
MOORE, WM. HARLEY	Jan. 9, 1900
Engineer of Bridges, N. Y., N. H. & H. R. R., New Haven, Conn.	
MORTON, WALTER S.	Aug. 10, 1904
Morton & Burritt Engineers, 2 Rector St., New York	
MOSS, ERNEST B.	April 20, 1901
Civil Engineer, H. Wales Lines Co., Meriden, Conn.	
MURPHY, HAROLD T.	Feb. 9, 1904
Civil Engineer, Springfield, Mass.	
MURPHY, JOHN P.	July 18, 1899
City Engineer's Office, Hartford, Conn.	
NASH, PAUL	Jan. 9, 1900
City Engineer and Surveyor, Stamford, Conn.	
NICHOLS, CHARLES H.	Jan. 8, 1901
Consulting Engineer and Engineer of Shell Fish Commission, New Haven, Conn.	
NOERR, ROBERT COLLYER	Feb. 12, 1907
Civil Engineer, Berlin Construction Co., Hartford, Conn.	
O'CONNOR, DON, Associate Member	Feb. 9, 1904
D. F. Keenan, Hartford, Conn.	
OLDERSHAW, FRANCIS H.	Jan. 8, 1901
City Engineer, New Britain, Conn.	
OLMSTED, C. HENRY	July 18, 1899
Civil Engineer and Surveyor, East Hartford, Conn.	
OLSEN, JOHN	Feb. 12, 1907
Civil Engineer, Springfield, Mass.	
OSBORNE, FRED H.	Jan. 9, 1900
Civil Engineer, Consolidated R. R., New Haven, Conn.	
OWEN, ELIJAH H.	March 30, 1900
Care of Vorce Engineering Co., Perry-Payne Bldg., Cleveland, Ohio.	
PALMER, GEORGE E.	March 30, 1900
Assistant Engineer N. Y., N. H. & H. R. R., West Haven, Conn.	
PALMER, SHEPARD B.	Jan. 8, 1895
Civil Engineer and Surveyor, Norwich, Conn.	
PALMER, WILLIAM B.	Jan. 13, 1885
Civil Engineer and Surveyor, Bridgeport, Conn.	
PARDEE, WILLIAM S., Associate Member	Aug. 10, 1904
Wright & Pardee, New Haven, Conn.	
PARKER, GEORGE A.	July 18, 1899
Superintendent of Keney Park, Hartford, Conn.	
PARSONS, HAROLD A.	Aug. 14, 1900
Civil Engineer, Stamford, Conn.	
PATTON, ARTHUR J.	Sept. 12, 1889
Land Surveyor, Waterbury, Conn.	
PEARSON, ROBERT L.	Aug. 14, 1906
Civil Engineer, Saugatuck, Conn.	

LIST OF MEMBERS.

155

PECK, ERMON M.	Jan. 8, 1895
Assistant Engineer Hartford Water Works, West Hartford, Conn.	
PECK, LEON F.	Oct. 11, 1902
Civil Engineer, Greenwich, Conn.	
PENDLETON, CLAUDIUS V.	Aug. 10, 1904
Civil Engineer, Newark, N. J.	
PENFIELD, GEORGE W.	Jan. 8, 1901
Civil Engineer, New Britain, Conn.	
PHELPS, JAMES W.	Oct. 11, 1902
Landscape Architect, Bolton, Conn.	
PIERCE, BRADFORD D., JR.	Aug. 23, 1905
Civil Engineer, Bridgeport, Conn.	
PIERCE, WILLIAM B.	Feb. 9, 1904
Civil Engineer, Stamford, Conn.	
PIERSON, STEPHEN C.	Jan. 13, 1885
Civil Engineer and Surveyor, Meriden, Conn.	
PIKE, ROBERT G.	Jan. 8, 1901
Street Commissioner, Middletown, Conn.	
PIKE, WILLIAM K.	Feb. 9, 1904
Civil Engineer, Danielson, Conn.	
POEHLANDT, WALTER	Feb. 12, 1907
Engineering Department, N. Y., N. H. & H. R. R., Waterbury, Conn.	
PRESTON, CHARLES HENRY, JR.	Feb. 12, 1907
Civil Engineer, N. Y., N. H. & H. R. R., Waterbury, Conn.	
PUNDERFORD, JOHN K.	Jan. 9, 1900
Gen. Manager, Connecticut Railway Co., New Haven, Conn.	
REYNOLDS, WM. B.	Aug. 14, 1900
Land Surveyor, Waterbury, Conn.	
RICE, ARTHUR W.	April, 1884
President Union Mfg. Co., New Britain, Conn.	
RICHARDS, WALTER H.	March 30, 1900
Engineer of Water and Sewer Departments, New London, Conn.	
RIGHTS, LEWIS D.	Aug. 10, 1904
Civil Engineer, 45 Broadway, New York City.	
ROBINSON, HALBERT G.	Jan. 11, 1898
Civil Engineer and Surveyor, Patten, Maine.	
ROBINSON, LEONI W.	Feb. 14, 1905
Architect, New Haven, Conn.	
ROBINSON, SEYMOUR N.	Feb. 9, 1904
Civil Engineer, Hartford, Conn.	
ROGERS, CHARLES EDWIN.	Feb. 12, 1907
Prof. Civil Engineering, Trinity College, Hartford, Conn.	
ROLLINS, ROBERT W.	Jan. 9, 1900
General Manager Hartford Electric Light Co., Hartford, Conn.	
ROOT, CLIFFORD ANSON	Feb. 12, 1907
Civil Engineer, Hartford, Conn.	
RUFF, JOHN S.	Feb. 12, 1907
Engineering Department, N. Y., N. H. & H. R. R., New Haven, Conn.	
RYDER, ELY M. T.	Jan. 9, 1900
Construction Engineer Consolidated Railway, New Haven, Conn.	
SAGE, GEORGE H.	Jan. 8, 1895
Vice President Berlin Construction Co., Berlin, Conn.	
SCHILLING, ALBERT H.	Aug. 14, 1906
Berlin Construction Co., New Britain, Conn.	

SELLARS, PHILIP	Feb. 3, 1902
Civil Engineer, New Haven, Conn.	
SHAUGHNESSY, JAMES F.	Feb. 12, 1902
Board of Water Commission, Hartford, Conn.	
SHAW, GEO. H.	Aug. 29, 1902
Assistant Engineer Board of Water Supply, 299 Broadway, N. Y.	
SHELDON, PAUL	Feb. 12, 1907
City Engineer's Office, Hartford, Conn.	
SIBLEY, CHARLES A.	Feb. 12, 1902
Civil Engineer, St. Louis, Mo.	
SLOCUM, CURTIS L.	Aug. 29, 1902
Assistant Engineer Bridges, N. Y., N. H. & H. R. R., New Haven, Conn.	
SMITH, FRANK M.	Aug. 29, 1902
Engineering Department, N. Y., N. H. & H. R. R. Co., Danbury, Conn.	
SMITH, GEORGE E.	Feb. 12, 1902
Assistant City Engineer, Derby, Conn.	
SMITH, WILLIAM G.	April, 1884
Civil Engineer and Surveyor, Waterbury, Conn.	
SNELL, EDWARD B.	Feb. 12, 1902
Civil Engineer, New Haven, Conn.	
SNELL, HARRY E.	Jan. 3, 1902
Civil Engineer, Brooklyn, N. Y.	
SOEHRENS, JOHN H.	Aug. 12, 1902
Civil Engineer, N. Y., N. H. & H. R. R., New London, Conn.	
SPENCER, NORMAN C.	Jan. 9, 1902
Spencer & Washburn, Civil Engineers, Hartford, Conn.	
SPENCER, WALTER T.	Jan. 9, 1902
Division Engineer, N. Y., N. H. & H. R. R., New Haven, Conn.	
SPERRY, A. WILLIAM	Jan. 9, 1902
Civil Engineer and Surveyor, New Haven, Conn.	
SPERRY, HARTLEY W.	Feb. 3, 1902
Associate Member, Shore Beach, Conn.	
STEARNS, ELMER V.	Oct. 11, 1902
Civil Engineer, Berlin, Conn.	
STILES, ELGAR H.	Oct. 11, 1902
Civil Engineer, N. Y., N. H. & H. R. R., Cos Cob, N. Y.	
STERLING, PAUL	Oct. 11, 1902
Civil Engineer, N. Y., N. H. & H. R. R. Co., New Haven, Conn.	
STODDARD, RAYMOND FRENCH	Jan. 9, 1902
Resident Engineer, Fall River and Somerset Bridge, Fall River, Mass.	
STONE, EDWARD M.	July 13, 1899
Civil Engineer and Surveyor, Hartford, Conn.	
STORY, ISAAC M.	Feb. 12, 1902
Civil Engineer, N. Y., N. H. & H. R. R., New Haven, Conn.	
SPORRS, HARRY W.	Aug. 23, 1902
Civil Engineer, Meriden, Conn.	
SULLIVAN, JOHN M.	Aug. 12, 1902
Civil Engineer, N. Y., N. H. & H. R. R., New Haven, Conn.	
TAYLOR, EDVY L.	Feb. 12, 1902
1825 State St., Albany, N. Y.	
TAYLOR, LUCIAN A.	June, 188-
Civil Engineer and Contractor, Boston, Mass.	
TAYLOR, WILLIAM T.	Feb. 3, 1902
Civil Engineer, Hartford, Conn.	

TERRY, ALFRED H.	Feb. 11, 1900
Division Engineer, N. Y., N. H. & H. R. R., New Haven, Conn.	
THOMAS, JAMES B.	Jan. 9, 1900
Civil Engineer and Surveyor, Hartford, Conn.	
TONER, JAMES A.	Aug. 23, 1905
City Engineer's Office, Meriden, Conn.	
TRACY, JOHN C.	Jan. 9, 1900
Assistant Professor of Structural Engineering, Yale University, New Haven, Conn.	
TRUESDELL, WALTER E.	June 11, 1898
Civil Engineer, 160 5th Ave., New York, N. Y.	
TRUMBULL, JOHN F.	Aug. 10, 1904
Civil Engineer, N. Y., N. H. & H. R. R., New Haven, Conn.	
TURNER, ALBERT M.	Aug. 10, 1905
Civil Engineer, Canaan White Lime Co., Canaan, Conn.	
UNKELBACH, MAX J.	Jan. 9, 1900
Architect and Civil Engineer, New Britain, Conn.	
VERRILL, GEORGE E.	Feb. 11, 1902
U. S. Assistant Engineer, New Haven, Conn.	
VORCE, CLARENCE B.	Jan. 10, 1899
John F. Kelly Engineering Co., New York City.	
WADHAMS, JOSEPH P.	Feb. 9, 1904
Civil Engineer, New Haven, Conn.	
WADSWORTH, A. R.	Oct. 27, 1886
Civil Engineer and Surveyor, Farmington, Conn.	
WARDWELL, FREDERICK S.	Feb. 9, 1904
Civil Engineer, Stamford, Conn.	
WASHBURN, ALBERT L.	Jan. 10, 1899
City Engineer's Office, Hartford, Conn.	
WATERMAN, CHARLES P.	Feb. 11, 1908
Civil Engineer, Bristol, Conn.	
WEAVER, HALSEY A.	Jan. 12, 1897
Civil Engineer, N. Y., N. H. & H. R. R., New Haven, Conn.	
WEBSTER, E. C.	Feb. 11, 1908
Civil Engineer, New Haven, Conn.	
WELTON, NELSON J.	April, 1884
Civil and Hydraulic Engineer, Waterbury, Conn.	
WILLIAMS, PHILIP K.	Aug. 14, 1906
Assistant Superintendent J. B. Williams Co., Glastonbury, Conn.	
WHEELER, CHAS. A.	Jan. 8, 1901
Prof. of Mathematics, Conn. Agricultural College, Storrs, Conn.	
WHITE, HOWARD E.	Feb. 9, 1904
New Haven Gas Light Co., New Haven, Conn.	
WHITNEY, ELI	March 30, 1900
President New Haven Water Co., New Haven, Conn.	
WHITON, FRANK W.	Feb. 14, 1905
Associate Member. Architect, Hartford, Conn.	
WIGGIN, ERNEST W.	March 30, 1900
Engineering Department, N. Y., N. H. & H. R. R., New Haven, Conn.	
WILCOX, RALPH M.	Jan. 8, 1901
Civil Engineer, Middletown, Conn.	
WILKES, J. K.	April, 1884
City Engineer, New Rochelle, New York.	
WOLCOTT, HENRY A.	July 18, 1899
Mechanical and Civil Engineer, Hartford, Conn.	
WOOD, CHAS. N.	Aug. 14, 1900
Civil Engineer, Norwalk, Conn.	

ALPHABETICAL LIST OF ADVERTISERS

Name	Business	Page
Aetna Life Insurance Co., The.....	Insurance	37
Alpha Portland Cement Co.....	Cement	2
Alsen Portland Cement Co.	Cement	4
American Pipe Manufacturing Co., The	Cast Iron Pipe and Contractors	3
Atlas Portland Cement Co., The	Cement	6
Balf Co., The Edward.....	Teaming and Contracting.....	45
Beattie John, The Est. of.....	Granite.....	43
Benvenue Granite Co.	Granite	23
Berger, C. L. & Sons.....	Engineering Instruments	38
Berlin Construction Co.	Steel Structures..... (back cover)	
Blakeslee, C. W. & Sons	Contractors	33
Brodie Co., William H.	Steel Rolling Doors, etc.	7
Buffalo Steam Roller Co.	Road Rollers, etc.	8
Chicago Bridge & Iron Works	Bridges and Tanks	31
Coldwell-Wilcox Co.	Valves and Machinery	28
Conard, William R.	Inspecting Bureau	38
Connecticut Trap Rock Quarries, The	Trap Rock	17
Consolidated Rosendale Cement Co., The.....	Rosendale Cement..... (inside front cover)	
Detroit Graphite Co.	Paint	46
Dixon Crucible Co., The Joseph	Paint	10
Eddy, George M. & Co.	Tapes	13
Edson Manufacturing Co.	Pumps	12
Engineering News, The.....	Magazine	5
Engineering Record, The.....	Magazine	22
General Fireproofing Co., The.....	Reinforcing steel, etc.	14
Grant, C. L.	Borings	26
Gurley, W. & L. E. Co., The	Engineering Instruments (inside back cover)	
Hammond, E. D.	Artesian Wells and Borings.....	22
Harrington, Robinson & Co.	Rails	44
Hartford Paving & Construction Co., The	Pavement and Concrete	15
Hassam Paving Co., The Connecticut.....	Pavements	30
Hendricks Co., S. E.	Commercial Register	16
Hering, Rudolf, and Fuller, Geo. W.	Hydraulic and Sanitary Engineers	17
Hunt & Co., Robert W.	Inspecting	47
Hydrex Felt & Engineering Co., The	Waterproofing	9
Keenan, D. F.	Crushed Stone	19
Keith, Herbert C.	Consulting Engineer	38
Keuffel & Esser Co.	Engineering Instruments, etc.	34
Kolesch & Co.	Engineering Instruments	42
Lines Co., The H. Wales	Sewer Pipe, Stone and Cement.....	20
Lorain Steel Co., The	Rails	24
Lufkin Rule Co., The	Tapes and Rules	17
McKenna, Dr. Charles F.	Inspecting	42
National Meter Co., The	Meters	11
National Paint Works.....	Paint	5
New York Brick & Paving Co., The	Vitrified Paving Brick	25
Norcross Bros. Co., The.....	Contractors	41
Ousatonic Water Power Co., The.....	Water Power	42
Pacific Flush Tank Co.	Miller Automatic Siphon.....	39
Putnam, H. E.	Blue Stone, etc.	47
Rail Joint Co., The.....	Rail Joints.....	27
Scherzer Rolling Lift Bridge Co., The	Lift Bridges.....	29
Scott Co., The T. A.	Marine Construction, etc.	32
Sessions Foundry Co., The.....	Sewer Castings, etc.	26
Soltmann, E. G.	Drawing Materials.....	45
St. Marys Sewer Pipe Co.	Vitrified Sewer Pipe.....	40
Stoddard-Brown Co., The	Engraving	45
Trinity College.....	Education	38
Tuttle, Morehouse & Taylor Co., The.....	Printers and Publishers.....	21
United Building Material Co.	Cement	18
U. S. Wood Preserving Co.	Pavements	36
Warner-Miller Co., The.....	Cement, Blue Stone, Sewer Pipe, etc.	35
Warren Brothers Co.	Bitulithic Pavement	48
Warren Foundry & Machine Co., The	Cast Iron Pipe	13

CLASSIFIED LIST OF ADVERTISERS

BLUE PRINTS.	
E. G. Soltmann, New York, N. Y.....	45
Keuffel & Esser Co., New York, N. Y.	34
BORINGS.	
C. L. Grant, Hartford, Conn.....	26
E. D. Hammond, Hartford, Conn.....	22
BRICK.	
The New York Brick and Paving Co., Syracuse, N. Y.....	25
The Warner-Miller Co., New Haven, Conn.....	35
BRIDGES.	
Berlin Construction Co., Berlin, Conn.....(back cover)	
The Scherzer Rolling Lift Bridge Co., Chicago, Ill.	29
Chicago Bridge and Iron Works.....	31
CAST IRON PIPE.	
The American Pipe Manufacturing Co., Philadelphia, Pa.....	3
Warren Foundry and Machine Co., Phillipsburg, N. J.	13
CEMENT.	
The Atlas Portland Cement Co., New York, N. Y.....	6
Alpha Portland Cement Co., Boston, Mass.....	2
Alsen Portland Cement Co., New York, N. Y.....	4
Consolidated Rosendale Cement Co., New York, N. Y.....(inside front cover)	
The Warner-Miller Co., New Haven, Conn.....	35
The H. Wales Lines Co., Meriden, Conn.....	20
United Building Material Co., New York and Boston.....	18
CONCRETE.	
The Hartford Paving and Construction Co., Hartford, Conn.....	15
CONSULTING ENGINEERS.	
Herbert C. Keith, New York, N. Y.....	38
Hering & Fuller, New York, N. Y.....	17
CONTRACTORS.	
The Hartford Paving and Construction Co., Hartford, Conn.	15
C. W. Blakeslee & Sons, New Haven, Conn.	33
The American Pipe Manufacturing Co., Philadelphia, Pa.	3
The Edward Balf Co., Hartford, Conn.....	45
The H. Wales Lines Co., Meriden, Conn.....	20
The Norcross Bros. Co., Worcester, Mass.....	41
CRUSHED STONE.	
Connecticut Trap-Rock Quarries, New Haven, Conn.....	17
D. F. Keenan, Hartford, Conn.....	19
C. W. Blakeslee & Sons, New Haven, Conn.....	33
DRAWING MATERIALS.	
W. & L. E. Gurley, Troy, N. Y. ....(inside back cover)	
Keuffel & Esser, New York, N. Y.	34
E. G. Soltmann, New York, N. Y.....	45
EDUCATION.	
Trinity College, Hartford, Conn.....	38
ENGINEERS' AND SURVEYORS' INSTRUMENTS.	
C. L. Berger & Sons, Boston, Mass.	38
George M. Eddy & Co., Brooklyn, N. Y.	13
W. & L. E. Gurley, Troy, N. Y.....(inside back cover)	
Keuffel & Esser Co., New York, N. Y.....	34
Kolesch & Co., New York, N. Y.....	42
The Lufkin Rule Co., Saginaw, Mich.	17
ENGINEERING MAGAZINES.	
The Engineering News, New York, N. Y.	5
The Engineering Record, New York, N. Y.....	22
ENGRAVING.	
The Stoddard-Brown Co., New Haven, Conn.....	45
EXPANDED METAL.	
The Warner-Miller Co., New Haven, Conn.....	35
FIREPROOFING.	
William H. Brodie Co., New York, N. Y.....	7
The General Fireproofing Co., Youngstown, O.....	14
FLUSH TANK.	
Pacific Flush Tank Co., Chicago, Ill.....	39
INSPECTING.	
Dr. Charles F. McKenna, New York, N. Y.	42
William R. Conard, Burlington, N. J.	38
Robert W. Hunt & Co., New York, N. Y.	47

INSURANCE.	
The Aetna Life Insurance Co., Hartford, Conn.	37
IRON, STEEL, ETC.	
Berlin Construction Company, Berlin, Conn.	(back cover)
The General Fireproofing Co., Youngstown, O.	14
Chicago Bridge and Iron Works, Chicago, Ill.	31
MARINE CONSTRUCTION.	
The T. A. Scott Co., New London, Conn.	32
METERS.	
The National Meter Co., New York, N. Y.	11
PAINT.	
Detroit Graphite Manufacturing Co., Boston, Mass.	46
Joseph Dixon Crucible Co., Jersey City, N. J.	10
National Paint Works, Williamsport, Pa.	5
PAVEMENTS.	
The Hartford Paving and Construction Co., Hartford, Conn.	15
The Connecticut Hassam Paving Co., New Haven, Conn.	30
The New York Brick and Paving Co., Syracuse, N. Y.	25
U. S. Wood Preserving Co., New York, N. Y.	36
Warren Bros. Co., Boston, Mass.	48
PRINTERS.	
The Tuttle, Morehouse & Taylor Co., New Haven, Conn.	21
PUBLISHERS.	
S. E. Hendricks Co., New York, N. Y.	16
The Engineering News, New York, N. Y.	5
The Engineering Record, New York, N. Y.	22
PUMPS.	
Edson Manufacturing Co., Boston, Mass.	12
RAILS.	
Harrington, Robinson & Co., Boston, Mass.	44
The Lorain Steel Co., Johnstown, Pa.	24
RAIL JOINTS.	
The Rail Joint Co., New York, N. Y.	27
ROAD ROLLERS.	
Buffalo Steam Roller Co., Buffalo, N. Y.	8
SANITARY ENGINEERS.	
Rudolph Hering and George W. Fuller, New York, N. Y.	17
SEWER CASTINGS.	
The Sessions Foundry Co., Bristol, Conn.	26
SEWER PIPE.	
St. Marys Sewer Pipe Co., St. Marys, Pa.	40
The H. Wales Lines Co., Meriden, Conn.	20
The Warner-Miller Co., New Haven, Conn.	35
STEEL ROLLING DOORS.	
William H. Brodie Co., New York, N. Y.	7
STONE	
Benvenue Granite Co., New York, N. Y.	23
The Estate of John Beattie, Leete Island, Conn.	43
Connecticut Trap-Rock Quarries, New Haven, Conn.	17
C. W. Blakeslee & Sons, New Haven, Conn.	33
The Warner-Miller Co., New Haven, Conn.	35
D. F. Keenan, Hartford, Conn.	19
The Norcross Bros. Co., Worcester, Mass.	41
The H. Wales Lines Co., Meriden, Conn.	20
H. E. Putnam, Hartford, Conn.	47
TANKS.	
Chicago Bridge & Iron Works, Chicago, Ill.	31
TAPES.	
C. L. Berger & Sons, Boston, Mass.	38
George M. Eddy & Co., Brooklyn, N. Y.	13
W. & L. E. Gurley, Troy, N. Y.	(inside back cover)
Keuffel & Esser Co., New York, N. Y.	34
Kolesch & Co., New York, N. Y.	42
E. G. Soltmann, New York, N. Y.	45
The Lufkin Rule Co., Saginaw, Mich.	17
VALVES AND HYDRANTS.	
Coldwell-Wilcox Co., Newburgh, N. Y.	28
WATER POWER.	
The Ousatonic Water Power Co., Derby, Conn.	42
WATERPROOFING.	
The Hydrex Felt & Engineering Co., New York, N. Y.	9
WELLS.	
E. D. Hammond, Hartford, Conn.	22

THESE Proceedings reach some 2500 engineers and contractors throughout the country. No like publication that we know of provides the same amount of advertising for so small an expenditure.

For rates and space, address

J. FREDERICK JACKSON,

Secretary, New Haven, Conn.

DO NOT FORGET OUR ADVERTISERS

THEY ARE ALL FIRST CLASS AND RELIABLE

PATRONIZE THOSE WHO PATRONIZE US

Please Mention this Publication in Addressing Them

Alpha Portland Cement

**THE RECOGNIZED
STANDARD
AMERICAN BRAND**

Alpha Portland Cement Co.

NEW ENGLAND DEPARTMENT

**521 and 522 Board of Trade Building
BOSTON, MASS.**

F. N. KINNEY, Manager

JOSEPH S. KEEN, JR.
President and General Manager

H. BAYARD HODGE
Secretary and Asst. Treasurer

GEORGE M. BUNTING
Vice President and Treasurer

WM. H. ROTH
Assistant Secretary

The American Pipe Manufacturing Company

Engineers and Contractors for Water Works

No. 112 NORTH BROAD ST.

PHILADELPHIA

J. W. LEDOUX, M. AM. SOC. C. E.
Chief Engineer

JAMES H. DAWES
Supt. of Construction

HAROLD PEROT KEEN
Supt. Operating Dept.

AMERICAN AND GERMAN

THE OLDEST MANUFACTURERS OF HIGH GRADE
PORTLAND IN THE WORLD. EXTRA QUALITY ALWAYS

ALSEN

AMERICAN

NEW YORK GERMAN

THE SIDEWALK CEMENT

EVERY barrel of **ALSEN'S** guaranteed unreservedly to exceed "Standard Specifications." A medium slow-set cement has proven in practical tests, in all countries, most **durable** and **safe**.

Forced strength, like forced growth, is **dangerous** to ultimate results.

We supply QUICK SET for special work only.

ALSEN'S is the **SAFEST** cement, as **Analyses** prove.

Every barrel passes boiling tests before shipped.

Every barrel is matured.

The **Panama Canal Award** by Isthmian Commission, the 70,000 bbl. City of Rochester contract, the Key West extension, and many works of nearly equal importance, without a single rejection under most rigid tests, substantiate every assertion made for this Portland. Just awarded the only contract ever let specifying over 1,000,000 bbls.—the Ashokan dam.

"CEMENT INSURANCE"

NATIONAL PAINT WORKS

Established 1876

WILLIAMSPORT, PA.

Railroad and Technical Paints

*Specialists in
Paints for Metal Surfaces*

Send to our Main Sales Office, at 100 William Street, New York City,
for a free copy of the Seventh Edition of the Review of Technical
Paints for Metal.

SOME IDEA OF THE VALUE OF
PROPOSAL ADVERTISING
IN
ENGINEERING NEWS

MAY BE GAINED FROM THE
FACT THAT DURING 1907 THERE APPEARED IN

ENGINEERING NEWS

OVER 87,000 LINES OF NOTICES OF
CONTRACT LETTINGS

WRITE FOR FURTHER INFORMATION

THE ENGINEERING NEWS PUBLISHING CO.

220 BROADWAY

NEW YORK, N. Y.

THE STANDARD AMERICAN BRAND

ATLAS PORTLAND CEMENT

ALWAYS UNIFORM

Productive Capacity, 40,000 Bbls. per Day

“Atlas” Portland Cement is manufactured from the finest raw materials, under expert supervision in every department of the works, and is specified by leading engineers in the United States.

THE ATLAS PORTLAND CEMENT CO.

30 Broad Street, New York City

Send for our books on concrete construction

"KINNEAR"

Steel Rolling Doors, Shutters and Partitions

INTERLOCKING SLAT CONSTRUCTION

Made in Nos. 16, 18, 20, and 22 U. S. Standard Gauges

USE BY

N. H. &
R. R. Co.

C. R. R.

& W. R. R.

h Valley

R. R.

. R. R.

&
Hudson

Island
R. R. Co.

any

rn

loads



IN USE BY

Brooklyn
Heights R. R.

Public Service
Corporation

Connecticut
Company

Hartford

Meriden

Greenville

Bridgeport
and Mystic

Norwich &
Westerly

and many
others in
various
sections

"KINNEAR DOORS" AS ADAPTED TO ELECTRIC RAILWAY CAR BARNS

*Also widely used in Factories, Warehouses, Pier Sheds, Power Plants, Dry Kilns,
Round Houses, Elevator Openings, etc.*

GENERAL EASTERN AGENTS:

WILLIAM H. BRODIE COMPANY
e for Catalogue 45 Vesey St., New York City

BUFFALO PITTS



Double Drive Tandem Roller

Tandem Rollers
Asphalt Rollers
Golf Rollers

Macadam Rollers
Combination
Rollers
Road Scarifiers
Etc., Etc.



Double Cylinder Macadam Roller

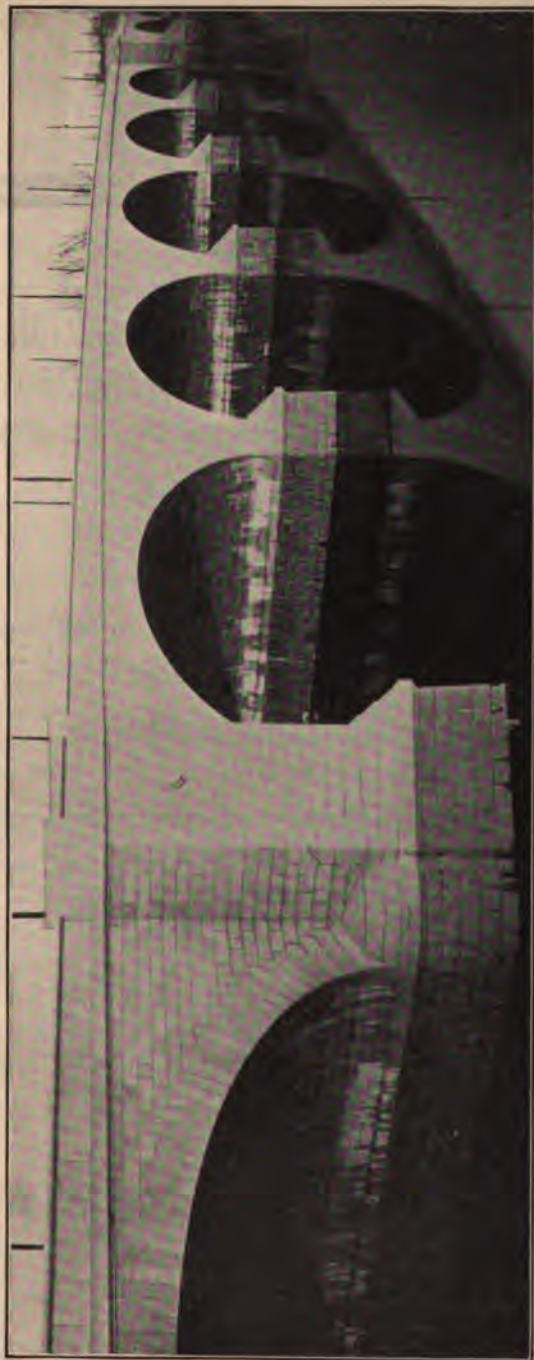
WRITE FOR CATALOG

BUFFALO STEAM ROLLER COMPANY
BUFFALO, N. Y.

EASTERN OFFICES

150 NASSAU STREET, NEW YORK CITY
15 COURT SQUARE : : BOSTON, MASS.

HYDREX



THE GREATEST STONE BRIDGE IN THE WORLD. Over the Connecticut River at Hartford, Conn.

All Arches Waterproofed with "Hydrex" Felt and Compound per "The Membrane Method"

The Highest Grade, Toughest and Most Elastic Waterproofing Made

HYDREX FELT AND ENGINEERING CO., Engineers and Experts in Waterproofing Problems, 120 LIBERTY STREET, NEW YORK



THE class of paint to specify and to use for the proper preservation of structural steel work has for years engaged the careful thought and investigation of engineers and architects.

The majority of engineers and architects throughout the world have for years specified and insisted upon the proper use of Dixon's Silica-Graphite Paint. "Standard of quality" has been the policy of the Joseph Dixon Crucible Company for eighty-one years, and Dixon's Silica-Graphite Paint, the proven shield for steel work, has won an important place in engineers' and architects' specifications, as the standard protective coating, on its records, as the paint made in but the one quality. Send for illustrations of structural steel work and paint literature.

Joseph Dixon Crucible Co.

JERSEY CITY

New England Office, 101 Tremont Street

BOSTON

The "AA" EMPIRE Water Meter

Have you
given it a trial ?

is receiving the
highest commendation
in all sections of the
country.

615,000

Meters

Made and Sold to Date

NATIONAL METER COMPANY

84 and 86 Chambers Street

NEW YORK

Boston: 159 Franklin St.

Chicago: 318 Dearborn St.

Pittsburg: 4 Smithfield St.

Los Angeles: 411 South Main St.



**Lift and Force Pump,
Nos. 8 and 10**



Trench Pump, Nos. 2, 3 and 4

EDSON PUMPS

Edson Diaphragm Pumps are used all over the world for raising large quantities of water full of gravel, sewage, etc., by hand power.

The Trench Pumps are in use by fully twenty-five per cent. of the railroads and water works in the United States, and by a large proportion of the excavating contractors. This is an open discharge pump, made in three sizes.

The Lift and Force Pumps, also made in three sizes, used by prospectors and miners, for deep trench work, odorless excavating, pile sinking, and for forcing cement into quicksands, are well worthy of your consideration.

Edson Pumps are portable and non-chokable, pumping anything liquid enough to flow.

Send for booklets telling what they have done for others.

EDSON MANUFACTURING CO.

250 Atlantic Avenue, - Boston, Mass.

ESTABLISHED 1859

GEORGE M. EDDY & CO.

345 to 353 Classon Avenue, Brooklyn, N. Y.

**COTTON TAPES
LINEN TAPES
STEEL TAPES**



Pioneers of the Tape Manufacturing Business in America

And the only firm giving its whole time and entire attention to the
manufacturing of tape measures

Warren Foundry & Machine Co.

ESTABLISHED 1856

Works at Phillipsburg, New Jersey

Sales Office, 170 Broadway, New York

Cast Iron, Water and Gas	PIPE	From 3 to 60 in. in diameter
-----------------------------	-------------	---------------------------------

**Also all Sizes of Flanged Pipe
and Special Castings**

The General Fireproofing Co.

System for Reinforcing Concrete

EVERYTHING STANDARDIZED



PIN-CONNECTED GIRDER FRAMES.

(PATENTED)

Complete Reinforcement for Reinforced Concrete Buildings, fabricated under the most favorable manufacturing conditions in our specially equipped shop, and erected in the forms by our own men.

SEND US YOUR PLANS FOR ESTIMATE

**For Every Reinforcing Requirement, we manufacture
a Specially Designed Material**

**COLD TWISTED LUG BARS TRUSSIT FOR ROOFS
WIRE FABRIC REINFORCEMENT
EXPANDED METAL**

We manufacture ALLSTEEL Furniture and Sectional Filing Equipment, including Engineers' Map and Plan Filing Cases.

Designs and Estimates promptly furnished

The General Fireproofing Co.

YOUNGSTOWN, OHIO

**Boston, 161 Devonshire St. New York, 10 East 33d St.
Philadelphia Washington New Orleans St. Louis Chicago San Francisco**

THE
HARTFORD PAVING

and

CONSTRUCTION CO.

703 Main Street
Hartford, Connecticut

Concrete Arches *and* Foundations

PAVEMENTS

OF ALL KINDS

Artificial Stone Sidewalks

Masonry, Sewers

*Protect the Joints in your
Concrete with the*

HARTFORD WATERPROOF JOINT, patented

and insure good work

Established 1891 350,000 Names and Addresses Over 1,300 Pages

Issued Annually Over 25,000 Classifications

THE SEVENTEENTH ANNUAL EDITION OF

Hendricks' Commercial Register

OF THE UNITED STATES

For BUYERS and Sellers

Will be Ready July 15, 1908

**Devoted to the Architectural, Electrical, Engineering, Iron
and Steel, Mechanical, Railroad, and Kindred
Industries of the United States**

This book is the most complete work of its kind ever issued. It includes all Professions and Trades interested directly or indirectly in the Mechanical, Electrical, Architectural, Engineering, Construction, Railroad, Iron, Steel, Machinery, Mill, Mining, and kindred trades.

In the lines we cover, every firm appears under its proper classifications, regardless of patronage.

It is invaluable to the Buyer or Seller, the Architect, Engineer, Contractor, Purchasing Agent, Manufacturer, Mine, Millman, Quarryman, Machine Shop, Boiler Shop, Rolling Mill, Foundry, Railroad, Electric Power and Lighting, Plantation, Ship Builder, Lumber Manufacturer or Dealer, Hardware Dealer, Planing Mill, and to every department of Municipal, State and National Government. There is not a Material, Specialty, Apparatus, or any kind of Machinery used in these vast industries under which the name and address of the Manufacturer does not appear properly classified. In fact, the work gives the name and address of the manufacturers of everything made from Iron, Steel, Brass, Bronze, Aluminum, Clay, Stone, Marble, Granite, Slate, Wood, Fiber, Asphalt, Asbestos, etc. In short, it enumerates every Finished Product manufactured from the above-named materials, not omitting the Professions that Specify, the Dealer who handles, the Manufacturers and Contractors who are consumers. This gives you in a nutshell the contents of our Commercial Register. It is bound in cloth and will be forwarded to any part of the country, expressage prepaid, on receipt of

PRICE, \$10.00

S. E. HENDRICKS COMPANY, Publishers

74 LAFAYETTE, CORNER FRANKLIN STREET, NEW YORK

Connecticut Trap-Rock Quarries

INCORPORATED

CRUSHED TRAP-ROCK

FOR BALLAST, MACADAM, CON-
CRETE, WALKS, DRIVES, ETC.

OFFICE

46 MEADOW STREET, NEW HAVEN, CONNECTICUT
HOTEL GARDE BUILDING

Shipments by Rail to all points reached by The N. Y., N. H. & H. R. R. Co.

Daily Capacity of Crushers, 4000 Tons

Cable Address
HYDOR, N. Y.

Lieber and Western Union Codes Used

Telephone Connection
4980 CORTLANDT

RUDOLPH HERING and GEORGE W. FULLER
Hydraulic Engineers and Sanitary Experts

SPECIALTIES

WATER SUPPLY SEWERAGE
WATER PURIFICATION SEWAGE DISPOSAL
REFUSE DISPOSAL

170 BROADWAY

NEW YORK



LUFKIN

TAPES AND RULES

ARE THE BEST IN THE WORLD.

Made by **THE LUFKIN RULE CO.**

NEW YORK. Saginaw, Mich., U. S. A.
LONDON, England.
WINDSOR, Canada. FOR SALE EVERYWHERE.

SEND FOR CATALOG

Giant Portland and Union Rosendale Cements

Manufactured by American Cement Co. of Pennsylvania

Important Work on Which these Brands were Used

New York Central & Hudson River Road.

New York, New Haven & Hartford R. R.

Pennsylvania System and Weehawken & Manhattan Shafts, together with North and East River Tunnels, now under construction.

Hudson Co.'s five tunnels under North River Atlantic Avenue Improvements, Brooklyn, N. Y.

Brighton Beach Railroad Improvements, Brooklyn, N. Y.

New Croton Dam and Aqueduct.

United Gas and Coke Co., Everett, Mass.

Boston Transit Commission, Boston, Mass.

Wachusett Dam, Clinton, Mass.

Jerome Park Reservoir, New York City.

Hall of Records, New York City.

Troop C, Armory, Brooklyn, N. Y.

Cross River Dam, Katonah, N. Y.

Re-Inforced Concrete Buildings

Automobile Co. of America, New York City, 7 sty. Garage.

Packard Motor Company, New York City, 6 sty. Garage.

Hodgman Rubber Co., Tuckahoe, N. Y., 5 sty. Factory.

McNulty Company, New York City, 10 sty. Warehouse.

Bowling Green Storage Co., New York City, 7 sty. Warehouse.

Wood Worsted Mills, Lawrence, Mass., 7 sty. Warehouse.

Mergenthaler Linotype Co., Bklyn., N. Y., 8 sty. Factory.

Hanan Shoe Company, Bklyn, N. Y., 6 sty. Factory.

Schwarzchild & Sulzberger, New York City, 5 sty. Stable.

R. H. Long Shoe Co., Framingham, Mass., 5 sty. Factory.

Commercial Trust Co., New York City, 6 sty. Bank and Office Bldg.

Boston & Albany Railroad, Boston, Mass., 7 sty. Warehouse.

1,500,000 Bbls. of these brands used exclusively in construction by
Rapid Transit Subway Cons. Co. in New York
City and Brooklyn

United Building Material Company

320 Broadway, New York City

101 Milk St., Boston, Mass.

Quotations Sent Upon Application

D. F. KEENAN

Crushed Trap Rock

**For MACADAM, BALLAST
CONCRETE DRIVEWAYS
ETC.**

Rough Wall Stone and Bottom Stone Very Cheap

**Four Crushers at Work at Quarry Near Newington
800 Tons Daily Capacity**

**Stone delivered by Electric Cars along all lines centering at Hartford
or dumped into carts at Bins rear of 173 State Street**

Telephone 1675

OFFICE: ROOM 21, WAVERLY BUILDING

721 Main Street - HARTFORD, CONN.

Represented by DON O'CONNOR

The H. Wales Lines Co.

MERIDEN, CONN.

DISTRIBUTOR OF

DEXTER PORTLAND CEMENT

Ulster County Rosendale Cement

VITRIFIED SALT-GLAZED SEWER PIPE

A full line of all sizes and fittings in stock for prompt delivery

BLUE STONE

PILING

GRANITE

Builders' and Contractors' Material

THE
TUTTLE, MOREHOUSE & TAYLOR
COMPANY

Printers, Bookbinders, Stationers

Southern Connecticut Agents for

YAWMAN AND ERBE MFG. CO.

Vertical and Sectional Filing Cabinets of all kinds

For Card Indexes, Invoices, Legal Documents, etc.

Portfolio Sections

Especially suited to the convenient filing of

MAPS AND BLUE PRINTS

Loose Leaf Binders

We Manufacture Special Sizes to Order

Loose Sheets for Binders

PRINTED, RULED AND PUNCHED TO ORDER

PRINTERY AND BINDERY, 123 TEMPLE STREET

STATIONERY STORE, 183 CROWN STREET

NEW HAVEN

CONNECTICUT

THE ENGINEERING RECORD

*The leading journal in the field of
civil engineering*

THE ENGINEERING RECORD is both authoritative and exhaustive on all features of municipal engineering, bridge and structural engineering, mill and power engineering, heating and ventilation, railway location and construction, and allied subjects.

Its articles reflect correctly the best standard practice in both design and construction. They also include descriptions of unusual works, making clear the reasons for their special features.

Published weekly with over 2,000 pages of reading matter per annum. Subscription price, \$3.00 a year.

Sample copies on request

THE ENGINEERING RECORD

239 West 39th Street

NEW YORK

E. D. HAMMOND

HARTFORD, CONN.

Foundation Borings Artesian Wells

WIND MILLS, ENGINES, TANKS AND TOWERS

Diamond Core Drilling

We remove uncertainty in foundation work by obtaining actual samples of all strata, whether same is sand, quicksand, gravel, clay, boulders or rock, etc.

Among others, we have made borings for—

U. S. Army Engineers, survey of Connecticut River and Providence River; Water Commissioners, Hartford, 4,100 lin. ft.; Bridge Commission, Hartford, 32 tests to bed rock; bridge, Derby, Conn.; Water Commissioners, Meriden, Conn.; Connecticut River Power Co., Brattleboro, Vt.; Tuttle Brick Co., Middletown, Conn.

BENVENUE GRANITE CO.

41 Park Row, New York, N. Y.

Granite—"Crotch Island," "Sullivan" and "Swan's Island"
for Building, Curb and Monumental Work

DESCRIPTION

"Crotch Island" Granite is light pink in color, which is perfectly uniform. It is a fine class of Granite and is suitable for every description of high-class building, monumental and curb work.

"Sullivan" Granite is of a light gray color, fine grained and uniform texture.

"Swan's Island" Granite is a beautiful shade of red of fine grain.

The Benvenue Granite Co. has quite recently installed at its quarries a complete outfit of Granite Cutting Machinery and accessories of the most modern description known to the Granite trade.

Our Motto is: Quick Deliveries

SEE OUR CURB ON THE NEW HARTFORD BRIDGE

The Lorain Steel Company

Girder Rails

High Tee Rails

High-Grade

Special Track Work

And Electrically Welded Joints

General Offices

Pennsylvania Building

Philadelphia, Pa.

Also Offices at

New York, N. Y., 30 Church St.	Chicago, Ill., Monadnock Block
Pittsburg, Pa., Frick Building Annex	St. Louis, Mo., Chemical Building
Atlanta, Ga., Equitable Building	Cleveland, Ohio, Rockefeller Building
San Francisco, Cal., Crocker Building	Philadelphia, Pa., Pennsylvania Building

JOHNSTOWN, PA.

The Celebrated Syracuse Vitrified Paving Brick

MANUFACTURED AT

SYRACUSE, NEW YORK

Eastern References: New Haven, Conn., and Springfield, Mass.

DEPARTMENT OF PUBLIC WORKS

Engineer's Office, Room 17, City Hall

New Haven, Conn., May 1, 1908.

*The New York Brick and Paving Co.,
Syracuse, N. Y.*

Gentlemen: The following streets or portions of streets, in this city, have been paved with "Syracuse" Brick:

In 1892. York St. (one side), bet. Chapel and Elm Sts.,	633.3 sq. yds.	Sand Joints
In 1893. Ashmun St., bet. Henry and Gregory Sts.,	2,432.1 " "	
In 1894. Chapel St., at and near State St.,	947.6 " "	
In 1900. Grand Av., bet. the Mill and Quinnipiac Rivers,	22,697.1 " "	
In 1900. Commerce St., bet. Cong. Av. and Whiting St.,	2,708.5 " "	
In 1901. Chapel St., bet. York and State Sts.,	13,491.8 " "	Grout Joints
In 1901. Congress Av., bet. George and Temple Sts.,	4,206.0 " "	
In 1901. Crown St., bet. State and Temple Sts.,	3,567.8 " "	
In 1901. Elm St., bet. State and York Sts.,	12,377.2 " "	
In 1901. George St., bet. State and Temple Sts.,	5,661.2 " "	
In 1901. Temple St., bet. Elm St. and Congress Av.,	7,480.0 " "	
In 1902. Olive St., bet. State and Water Sts.,	10,341.0 " "	
Total - - - - -	87,546.7 " "	

In 1896-7 about seven miles of "Syracuse" brick gutters for macadam and asphalt pavements were laid. During the year 1902, 545,000 "Syracuse" brick were purchased by the city for repairing pavements not originally laid with "Syracuse" brick. None of the above-named localities has been repaired excepting where the pavement was torn up for specific purposes. The above total area represents about four miles of streets.

Very truly yours,

HENRY J. KELLOGG,

Assistant City Engineer,

New Haven, Conn.

Test Borings==Exact Samples

CORE DRILL BORINGS FOUNDATION TESTS

FOUNDATIONS FOR HEAVY ENGINEERING STRUCTURES INVESTIGATED

Samples of all materials penetrated saved for record and inspection. Samples of sand, gravel, quicksand, clay, hardpan, etc., shown in same condition as it is from where it is taken.

CORE SAMPLES FROM ROCK

Samples from various strata of rock encountered for investigating the nature and extent of rock in new quarries, mines, etc. The actual stone is brought up for inspection.

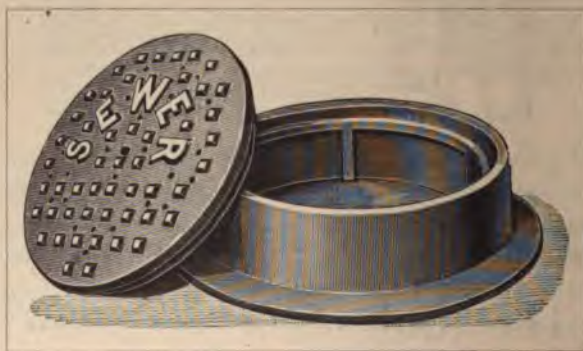
**Artesian Wells, Wind Mills, Pumps, Drilling Machinery, Well Supplies,
Elevated Tanks for Sprinkler System of Fire Protection**

C. L. GRANT

58 Belden St., Hartford, Conn. 17 Byron St., Providence, R. I.

The Sessions Foundry Co.

BRISTOL, CONNECTICUT



*Low
Prices*

**Sewer and Subway Manhole Castings
Sewer Catch Basin Castings, etc.**

*To
Order*

Prompt Shipments

Write us for estimates

Delivery at any point

Over 25,000 Miles in use

Showing the unprecedented approval of the
Base Supported Rail Joint by Railway Managers



Weber Joint

MADE FROM
ROLLED STEEL
TO FIT OVER 125
SECTIONS OF
RAILS



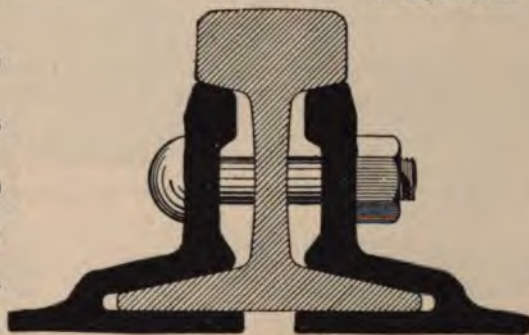
Wolhaupter Joint

Received the
Highest
Awards

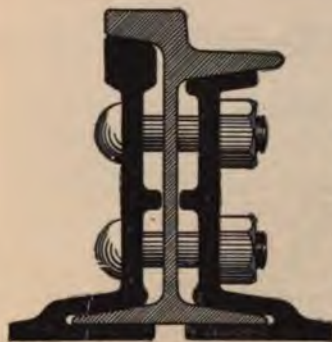
Paris, 1900

Buffalo, 1901

St. Louis, 1904



Continuous Joint



Continuous Girder Joint

Catalogs Furnished at All

SELLING AGENCIES

Baltimore, Md.

Pittsburg, Pa.

Boston, Mass.

Portland, Oregon

Chicago, Ill.

Seattle, Wash.

Denver, Col.

St. Louis, Mo.

New York, N. Y.

St. Paul, Minn.

Troy, N. Y.

The Rail Joint Company

GENERAL OFFICES:

29 West 34th Street, New York City

Makers of Rail Joints for Standard and Special Rail Sections, also Girder, Step or
Compromise, and Insulating Rail Joints, protected by Patents
in United States and Foreign Countries.

Sluice

Gates

ALL SIZES FOR ALL PURPOSES

Estimates and Specifications submitted for Hand, Hydraulic or
Electrically Operated Gates



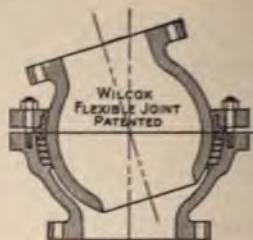
CIRCULAR GATE



RECTANGULAR GATE

Wilcox Patent Flexible Joints

Successfully Used on U. S. Government Hydraulic Dredges
and for Steam Purposes



Coldwell-Wilcox Company

NEWBURGH

NEW YORK

SCHERZER ROLLING LIFT BRIDGES

are Modern, Scientific, Safe, Simple, Economical and Efficient, and are superseding and replacing swing bridges and other old and obsolete types of movable bridges for railroads, electric railways and highways in all parts of the World.



Scherzer Rolling Lift Bridge across West River at Kimberly Avenue, New Haven, Conn.



Scherzer Rolling Lift Bridge across Newtown Creek at Vernon Avenue, New York City.

More than 100 swing bridges have already been condemned, removed and replaced by modern SCHERZER ROLLING LIFT BRIDGES in Greater New York, Chicago, Boston, Cleveland, Buffalo, Saginaw, New Haven, Peoria, Gloucester, Manistee, Fall River, Cambridge, Marseilles, St. Petersburg, Russia, and many other progressive cities in the United States and Abroad.

Highest Award World's Fair, St. Louis, 1904

Write us for Information, Photographs, Sketches and Estimates

THE SCHERZER ROLLING LIFT BRIDGE COMPANY

Main Offices: Monadnock Block, Chicago, U. S. A.

Cable Address
SCHERZER, CHICAGO

Eastern Office
220 BROADWAY, NEW YORK

The Leading Pavement

The following is an extract from the "Municipal Journal and Engineer," of March 4, 1908:

Relative Amounts of Various Pavements

"In New England we find eleven different kinds of paving, aside from macadam. Of these, stone block leads in quantity, and the others arrange themselves in the following order: gravel, brick, cobblestone, bitulithic, asphalt, Hassam, wood-block, asphaltine, asphalt block and bituminous macadam.

"Last year the largest amount of paving was stone block, followed by Hassam, gravel, brick, bitulithic and wood-block, in the order given."



HASSAM PAVEMENT ON OAK STREET, NEW HAVEN, CONN.

Laid by The Connecticut Hassam Paving Co.

Information and estimates for this most popular kind of pavement furnished on application to

The Connecticut Hassam Paving Company

902 Chapel Street, New Haven, Conn.

Metal Tanks

We are the builders of those hemispherical bottom elevated steel tanks which you have probably noticed in various parts of the country. We have done work of this character in 44 states and territories of the United States, in 6 of the provinces of Canada, in Mexico, Cuba, the Panama Canal Zone and the Philippine Islands.

The illustration shows a structure which we recently built for the Louisville Water Co., of Louisville, Ky. This is



the largest tank of its kind in the world, having a capacity of 1,200,000 gallons and a height of 220 feet from the top of foundations to the maximum water line of the tank.

We are prepared to design, manufacture and erect these tanks of any practical dimensions in any part of the world.

Our booklet, "Metal Structures," mailed upon request.

Chicago Bridge and Iron Works

105th and Throop Streets :: Chicago, Illinois

== THE ==

T. A. SCOTT CO.

**Wrecking and Salvage Operations of Every Character
Contractors in Marine
Construction**

**Steel, Concrete and Wood Sheet Piling
Bridges, Cofferdams, Foundations
Marine Railways, Wharves and Seawalls**

**DREDGING, TOWING
DIVERS AT SHORT NOTICE**

NEW LONDON - - - - - CONN.

TELEPHONE DAY OR NIGHT

C. W. Blakeslee

D. A. Blakeslee

Clarence Blakeslee

C. W. BLAKESLEE & SONS

58 Waverly Street, New Haven, Conn.

General Contractors

*Experts in Street Paving and
Macadam Road Making*

Steam and Electric Railroads, Dams, Sewers
and Heavy Masonry Built

Building Stone, Crushed Stone and Belgian Blocks Furnished

K & E ENGINEERING INSTRUMENTS

Transits, Levels, Rods, Tapes, etc.



are used on nearly every important engineering work, government, municipal and private. They excel in design, workmanship, accuracy and durability, and represent the latest progress in the art of making Instruments of Precision.

Our
PARAGON
Drawing Instruments

enjoy an excellent and wide reputation. They are the best instruments made.



We also carry KEY and other well-known brands.



We make the K & E Tapes: steel, metallic, linen and cotton. Also Band Chains, Flat Wire and Pocket Tapes. Greatest accuracy, largest assortment, all goods warranted.

Our pocket-sized 1908 Ephemeris sent free on request.

KEUFFEL & ESSER CO.

127 Fulton Street
New York

General Office and Factories
Hoboken, N. J.

Chicago, 111 E. Madison St.

St. Louis, 813 Locust St.

San Francisco, 48-50 Second St.

EXPANDED METAL

AND TWISTED STEEL RODS

FOR REINFORCING CONCRETE

**ATLAS AND GIANT
PORTLAND CEMENTS**

SEWER PIPE



BLUESTONE

EXPANDED STEEL LATH

PAVING BRICK

**PROMPT DELIVERIES MADE FROM STOCK AT
NEW HAVEN**



BROADWAY, NEW YORK, PAVED WITH U. S. WOOD BLOCKS

U. S. WOOD BLOCKS

"The Silent Pavement"

The paving of the greatest business street and the most densely populated thoroughfare in the world with U. S. Wood Blocks marks a new era in American street paving.

Hereafter, with the object lesson of lower Broadway before them, Americans everywhere will insist that, like Broadway under the new conditions, their streets of business travel shall be silent instead of frightfully noisy, clean and smooth for pedestrians and long wearing for the sake of the taxpayer.

The introduction of U. S. Wood Block pavement on Broadway and most of the business streets in lower New York has added immeasurably to the attractiveness of the city and has resulted in many petitions for the extension of wood block pavement to all districts.

Many other cities are also adopting this form of pavement, and it promises soon to be in universal use in the large modern cities and towns of the country.

Send for free booklets.

U. S. WOOD PRESERVING CO., 29 Broadway, New York

Ætna Liability Insurance

protects the insured against worry and expense caused by accidents, and prevents accidents by careful inspection and recommendation of effective safeguards.

ACCIDENT AND LIABILITY DEPT.

ÆTNA LIFE INSURANCE CO.

OF HARTFORD, CONN.

Ætna Accident Insurance

furnishes indemnity for loss of life, limb, sight or time caused by bodily injury. Double indemnity for accidents of travel.



C. L. BERGER & SONS,

37 William St., BOSTON, MASS.

SPECIALTIES :

Surveying Instruments of Precision.

ALL KINDS.

ALL SIZES.

Catalog on Application.

WILLIAM R. CONARD

Assoc. Amer. Soc. C. E., Assoc. M. Amer. Soc. M. E.

Inspector of R.R. & Bridge Materials, Building Materials,
Iron and Steel, Cast Iron, etc.

Specialty Inspection of Pipes and Spokes and all Water
Works Materials.

322 High Street

BURLINGTON, N. J.

Department of Civil Engineering at Trinity College

LECTURE COURSES IN
STRUCTURAL STEEL, BRIDGE, AND PIPE
DESIGN, AND
DESIGN OF STEEL, BRIDGE, AND PIPE
DESIGN, AND

HERBERT C. KEITH

Professor of Civil Engineering,
Trinity College, Hartford, Conn.

Author of "Structural Steel, Bridge, and Pipe Design,"
and "Design of Steel, Bridge, and Pipe Design."

185 N. 3rd St.,

NEW YORK

NEW YORK

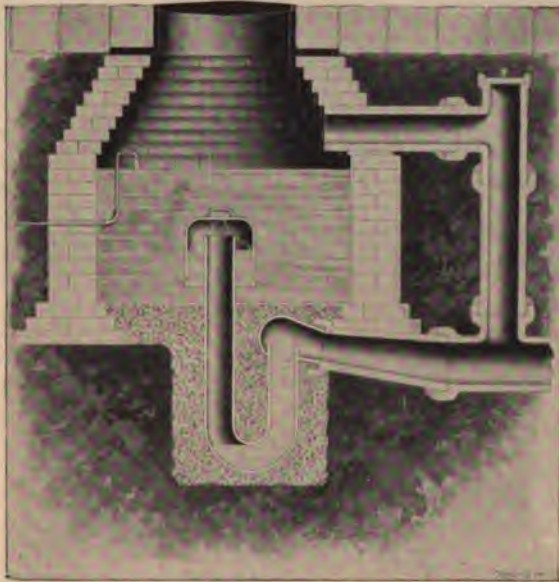
PACIFIC FLUSH TANK COMPANY

84 LA SALLE STREET, CHICAGO, ILL.

Manufacturers of the

Miller Automatic Siphon

FOR INTERMITTENT FLUSH TANKS



Used for Flushing Street Sewers

No Moving Parts No Joints No Little Traps

*Received the Highest Award in its Class at the World's Columbian Exposition
for Simplicity of Construction, Effectiveness and Reliability*

NEW HAVEN, CONN., March 1st, 1908,

The sewage filtration plant for Springside Home, New Haven, is equipped with an eight-inch special Miller Siphon, and has worked satisfactorily since put into operation. September 23, 1899.

(Signed) H. J. KELLOGG, C. E.

Each Siphon Guaranteed Absolutely

Send for Illustrated Catalogue

FRANK OBERKIRCH, *President*

GEORGE C. SIMONS, *Sec'y and Treas.*



St. Mary's Sewer Pipe Co.

*Sewer Pipe, Flue Linings
and all other clay products*

St. Marys, Pa.

Long Distance Telephone





SECTION OF GRANITE BRIDGE ACROSS THE CONNECTICUT RIVER, HARTFORD

EDWIN D. GRAVES, *Chief Engineer*

JOHN T. HENDERSON, *Deputy Chief Engineer*

McMULLEN, WEAND & McDERMOTT, *Contractors*

The Norcross Brothers Company

General Contractors and Builders

PRODUCERS OF

Vermont, New Hampshire, Massachusetts and Connecticut
Granites

Home Office: Worcester, Mass.

Offices:

New York

Boston

Providence

Washington

The stone for the Hartford Bridge, approximating 500,000 cubic feet, was furnished by us from our Branford Red Granite Quarries, Stony Creek, Connecticut.

The polished granite shaft, weighing 106 tons, in Battle Monument, West Point, N. Y., was furnished from the same quarry.

The Sault Ste. Marie obelisk, weighing 80 tons, also was furnished from this quarry.

The Ousatonic Water Power Company
Permanent and Reliable Water Power

DIRECT OR ELECTRICALLY APPLIED

The Best and Cheapest Power Known for Manufacturing Purposes

*Located at Derby and Shelton, Connecticut, and acknowledged as one
of the Best Water Powers in the Country*

TWO hours from New York, via N.Y., N.H. & H.R.R. Railroad and Tidewater transportation. The many natural advantages of location, supplemented by cheapness and permanency of power, variety of industries, skilled labor, facilities for transportation and close proximity to other large manufacturing communities, combine to make Derby and Shelton, as they are, an industrial center unequalled and unsurpassed by any city or town in New England, and where the manufacturer can safely, conveniently, and advantageously locate his business.

Inquiries relative to advantages of location, factory sites and power, will receive prompt attention.

The Ousatonic Water Power Co.

DERBY, CONNECTICUT



JUST RIGHT

Pioneer Transits, for preliminary and rapid work, are constructed with an eye on portability. Other Surveying and Engineering Transits, Levels and Drawing Materials

Send for our Catalogue

KOLESCH & CO.

Established 1885

138 FULTON ST.

NEW YORK

CHEMICAL AND PHYSICAL LABORATORIES

OF

DR. CHAS. F. McKENNA

Office, HUDSON TERMINAL BUILDING

FULTON AND CHURCH STREETS

NEW YORK CITY

Headquarters for Standard Tests of Materials, Specifications, Inspection and Control on great works, and for Expert Services in Chemical Engineering.

PETER BEATTIE, Exr.

JOHN BEATTIE, Jr., Exr.

... THE ...
ESTATE OF JOHN BEATTIE
GRANITE QUARRIES

AT LEETE ISLAND AND HOADLEY'S NECK

OFFICE AND WORKS, LEETE ISLAND, CONN.

Are well equipped to furnish Plain or Dressed
Granite in Large Quantities, by rail or water
shipment. Among others, have supplied Granite
for following constructions: :: :: ::

Piers, Connecticut River Stone Bridge, Hartford, Conn.
Soldiers' and Sailors' Monument, Riverside Drive, N. Y.
The New Third Avenue Bridge, 130th St., N. Y. City
Pedestal, Statue of Liberty, - New York Harbor
General Anderson Monument, - Pittsburgh, Pa.
General Flower Monument, - New York City
N. Y., N. H. & H. R. R. Co. Improvement, Bridgeport, Ct.
Residences, - - - - Newport, R. I.
New Plaza Hotel, - - - - New York City
Breakwaters at Block Island, Duck Island, New Haven,
Bridgeport, etc., etc.

**FOUR VESSELS WITH STEAM POWER TO
HANDLE HEAVY MATERIAL**

WHARTON SPECIAL TRACK WORK
OF SUPERIOR DESIGNS
FOR ALL CLASSES OF SERVICE

MANGANESE
STEEL
TRACK WORK
IS OUR SPECIALTY

W. M. WHARTON JR. & CO.
INCORPORATED
PHILADELPHIA, PA. JENKINTOWN PA.

NEW ENGLAND REPRESENTATIVES:

HARRINGTON, ROBINSON & CO.
272-276 FRANKLIN STREET-BOSTON, MASS.

EVERYTHING FOR ELECTRIC RAILWAY TRACK CONSTRUCTION
STEEL BRIDGES-ROOF TRUSSES-STRUCTURAL STEEL

The Edward Balf Company

26 STATE STREET, HARTFORD, CONN.

GENERAL TRUCKMEN
AND CONTRACTORS

MOSLER SAFES DELIVERED

BUILDING STONE

CRUSHED STONE

SAND

GRADING

EXCAVATING



E. G. SOLTMAHN
125 E. 42d St., New York, N.Y.
Next to Grand Central Station

Continuous Prints made from PROFILES

drawn on transparent Profile or
Cross Section Tracing Paper

PRICES for Large Prints up to $4\frac{1}{2}$ x 12 feet

BLACK Prints on Paper, per sq. ft.,	3c
" " Cloth, " " "	5c
BLUE " " Paper, " " "	2c

DRAWING MATERIALS

BLUE PRINT PAPER

Use INKOFF for Tracing Cloth Corrections
Trial Outfit sent for SIX 2c Stamps

The Stoddard-Brown Co.

ENGRAVERS

66 CENTER STREET

NEW HAVEN, CONNECTICUT

TO Engineers, Architects, Manufacturers and others interested
in the preservation of Iron or Steel Structures from Corrosion

We will cheerfully furnish upon application an Illustrated
Book. Showing Bridges and Buildings on which

Superior Graphite Paint

has been used

Interesting Tests and References are also given

It is hoped that prospective users of paint, not familiar with
this product, will investigate its merits before purchasing.
It is particularly adapted to withstand severe conditions.

Immediate Shipments made from Local Stock

Used on many bridges and buildings in Connecticut, to
which we would be glad to refer

DETROIT GRAPHITE COMPANY

PAINT MAKERS

141 Broadway, New York

1117 Tremont Bldg., Boston, Mass.

ROBERT W. HUNT & CO.

ENGINEERS

TEST MATERIALS, INSPECT FABRICATION, SUPERVISE ERECTION

STRUCTURES OF EVERY DESCRIPTION

EXAMPLES:

BUILDINGS

Metropolitan Life Ins. Co. Bldgs.
Apthorpe Apartment Bldgs.
B. Altman "
Gorham Mfg. Co. "
Tiffany & Co. "
Singer Mfg. Co. "
Sixty Wall Street "

VAULTS

Sub Treasury, Wall Street
34th Street National Bank
Van Norden Trust Co.
Windsor Trust Co.
Liberty National Bank
Bankers Trust Co.
Seligman & Co., Bankers

REPRESENTATIVE BUILDINGS IN ALL THE LARGE CITIES
OF THE UNITED STATES

LABORATORIES

PHYSICAL, CHEMICAL, CEMENT

New York
Philadelphia
Washington
Montreal

Pittsburgh
New Orleans
Buenos Ayres
London

Chicago
St. Louis
San Francisco
Mexico City

H. E. PUTNAM

Wholesale and Retail Dealer in

Bluestone, Flagging and Cut Stone

GRANITE CURBING, WALL STONE
CELLAR STEPS and PAVING BLOCKS

Setting of Flagging and Curbing a Specialty

Lime, Cement, Masons' Supplies, Sewer Pipe
and Flue Lining

**Office and Yard, 156 Woodland Street
HARTFORD, CONN.**

Telephone Connection

Furnished Curb for new Riverside Boulevard at Hartford

There is But One

Bitulithic pavement, and that one is the durable, sanitary and non-slippery street surface, prepared and laid under the patented formulae and processes of Warren Brothers Company. The numerous attempts to imitate Bitulithic have invariably resulted in failure. It is the one smooth pavement which stands for uniformity and quality. Bitulithic is the ideal roadway. City Engineers should familiarize themselves with Bitulithic. Full information for the asking.

Warren Brothers Company

BOSTON, MASSACHUSETTS

REGISTERED TRADE MARKS

"Bitulithic," "Punitan," "Bitrock," "Bituminous Macadam," "Bitustone"

ESTABLISHED 1843

INCORPORATED 1900

W. & L. E. GURLEY

TROY, NEW YORK

LARGEST MANUFACTURERS IN AMERICA OF

Civil Engineers' and Surveyors' Instruments

Y Levels, Compasses, Leveling Rods, Chains, Transits, Plane Tables,
Current Meters, Etc.



No. 76 Surveyors' Transit, \$133.00

Illustrated Catalogues mailed on application

Please mention the Report of the Connecticut Society of Civil Engineers
when writing

D. E. BRADLEY
President

GEORGE H. SAGE
Vice President

SEYMOUR N. ROBINSON
Treasurer

Berlin Construction Company

STEEL BUILDINGS, BRIDGES
AND STRUCTURAL WORK



STEEL-CONCRETE CONSTRUCTION A SPECIALTY

OFFICE AND WORKS: BERLIN, CONN.

220 Broadway
NEW YORK

131 State Street
BOSTON, MASS.

104 Market Street
NEWARK, N. J.

SEP 18 1909

25

★ CONNECTICUT SOCIETY
OF
CIVIL ENGINEERS



1909

VIA

Genuine Rosendale Cement



Used in the construction of nearly all the
Yale Buildings, New Haven, Conn.

Over one hundred miles of sewers in New Haven
were built with Rosendale

ONE PROMINENT ARCHITECT WRITES

"I have uniformly specified and insisted on your Cement, sometimes when others would have been easier to get, and have found it superior for floor work to Portland."

CONSOLIDATED ROSENDALE CEMENT CO.

GEO. G. CLEASON, Sales Agent

50 Church Street

New York City

Connecticut
Society of Civil Engineers



Papers and Transactions for 1908

AND

Proceedings

OF THE

Twenty-Fifth Annual Meeting

AT

HARTFORD, FEBRUARY 9 AND 10, 1909



New Haven

THE TUTTLE, MOREHOUSE & TAYLOR COMPANY

1909

Connecticut Society of Civil Engineers

ORGANIZED AT BRIDGEPORT, JANUARY 15, 1884

—•••—

Officers for 1909

FREDERICK J. EASTERBROOK, NEW HAVEN, . . . *President*
SHEPARD B. PALMER, NORWICH, . . . *First Vice President*
CHARLES A. FERRY, NEW HAVEN, . . . *Second Vice President*
J. FREDERICK JACKSON, NEW HAVEN, . . . *Secretary and Treasurer*
ROBERT N. HOSLEY, NEW HAVEN, . . . *Assistant Secretary*

Directors

GEORGE K. CRANDALL, NEW LONDON.
JOHN K. PUNDERFORD, NEW HAVEN.
HENRY J. KELLOGG, NEW HAVEN.
EDWARD W. BUSH, HARTFORD.

CONTENTS.

The Engineer in Court. By Edward W. Bush	1
Discussion	7
Conservation in the Use of Wood. By H. S. Betts.....	26
Notes on the Cost of Constructing Sewers. By J. Frederick Jackson.	41
The State Street Overflow Sewer, New Haven. By Henry J. Kellogg	55
Discussion	69
Index System for City Engineers' Offices. By William Gavin Taylor	70
Tunnel and Concrete Sewers at Hartford. By Roscoe N. Clark.....	77
Discussion	91
Reinforced Concrete Locomotive House at Waterbury. By G. Milton	
Poley	93
Concrete in the New Arsenal and Armory at Hartford, By W. A.	
Payne.....	103
Discussion	110
Stray Thoughts on Bridge Design and Maintenance. By Herbert C.	
Keith	115
Discussion	125
In Memoriam.....	136
PROCEEDINGS:	
Report of Board of Direction	138
Secretary's and Treasurer's Reports	139
Special Committee Report	141
President's Address	141
Election of Officers	149
Constitution and By-Laws.....	155
List of Members	163

LIST OF EX-PRESIDENTS

WITH DATES OF SERVICE

B. HULL.....	1884, 1885
CHARLES M. JARVIS	1886
CHARLES E. CHANDLER	1887
CHARLES H. BUNCE	1888, 1889
F. FLOYD WELD.....	1890
E. P. AUGUR	1891, 1892, 1893, 1894
WM. G. SMITH	1895, 1896
ROBERT A. CAIRNS.....	1897, 1898
EDWIN D. GRAVES	1899, 1900
HENRY J. KELLOGG	1901
CLARENCE B. VORCE	1902
FREDERICK L. FORD.....	1903
JOHN K. PUNDERFORD.....	1904
ALBERT B. HILL.....	1905
CHARLES F. CHASE.....	1906
DANIEL S. BRINSMADE.....	1907
EDWARD W. BUSH	1908

THE ENGINEER IN COURT.

By Edward W. Bush, Mem. Conn. Soc. C. E.

A very large part of the construction work in which civil engineers are engaged is work which is being built by contractors who have executed a contract with a firm, corporation, or others by which the contractor agrees, for a stipulated sum, to furnish certain materials and perform certain labors, etc., in a manner set forth in the contract and specifications and agreed to by the contracting parties. Generally an engineer, after preliminary studies, designs the work, prepares plans and specifications and later superintends the construction of the work. In drawing the contract and specifications, and at various times during the construction, the engineer will need the services of a good lawyer; also, if suit is started for breach of contract, the lawyer will need the help of the engineer in preparing the case for court. The services of the two are often very intimately associated, and the subject may well be studied by engineers, as they may be called upon at any time to act as witnesses or prepare data for use in court. In this paper the writer offers some suggestions regarding the collection and presentation of engineering data for court use which he hopes may be of some interest and which may bring out further discussion on the subject.

Construction of an engineering work by contract seems quite a simple matter. The engineer has described (or thinks he has described) just what work or materials are demanded and the drawings show the location and form of construction. The contractor has (or says he has) looked the ground over very carefully and puts in his bid after a study of the specifications. But often after the contract is signed and work has commenced the engineer will order something done that the contractor thinks is outside of his contract and trouble has started. Many contractors, if they have lost money on the job, are apt to start suit to recover for alleged extras about the time the work is finished, claiming that an additional verbal contract has been established, and the engineer may suddenly be called upon to prepare data

for a lawsuit and go into court as witness for the defense. Some contracts run along for several years before completion, and if data is required concerning the earlier part of the work, the engineer is very seriously handicapped, unless he has kept up daily records during construction of information which might later be needed in court.

The engineer, by the terms of the contract, is in many ways the authorized agent of the owner, and he should keep such data during construction that if called upon he can go into court with full information as to just what methods, materials or labor has gone into the work. If suit is started, probably the contractor will present time books, pay rolls, receipted bills for materials and a mass of records, all of which go to show that the cost to him was very much in excess of what he received and that he was forced into this extra expense because the engineer made him use materials or do work of a much higher grade than that specified. It takes good preparation and expert legal services to successfully defend a suit against such evidence, especially if the trial is before a jury. The construction engineer should bear in mind that a lawsuit may come at the end of every contract and keep his records accordingly. In justice to the large and growing body of honorable men now engaged in contracting, especially those doing the higher grade of work, it should be said that they perform their work in an honest, thorough and first-class manner and hesitate to commence suit unless they believe themselves grossly wronged. But often conditions arise in contract work over which there is an honorable difference of opinion which can only be determined by a judicial interpretation of the contract.

Often a dispute will arise because the contract drawings and specifications are not definite and later the contractor is asked to perform a certain grade of work at places not shown or indicated to him before he bid on the work. An eminent lawyer has said that when a contract is made between parties its items express "the common meeting of two minds." A copy of the contract with contract drawings attached is very apt to be Exhibit A when a suit is started, and an engineer should bear this in mind when drawings and specifications are being prepared and see that there is nothing that would lead to erroneous impressions if same were taken into court. The same may be said regarding

additional sketches, or plans given contractors during construction. Whenever such additional drawings are furnished contractors, they should be marked so that they will plainly indicate that they are explanatory or detail drawings and supplement the more general or contract drawings.

During construction the engineer will doubtless collect data regarding costs, tests made, methods used, time required to do certain parts of the work and other information which is of great interest and value to him as an engineer; but unless he has kept such records duly authenticated he may find them of little value to him in a lawsuit. The lawyers insist on facts which may be proven in court and are very quick to differentiate between facts and opinions. A diary kept by the engineer recording the daily progress of all parts of the work, a general record of methods used and containing an account of all conferences between interested parties, instructions given, personal inspections made and any other information bearing on the work which seems at the time to be worth recording, will be found of inestimable value in preparing for a suit. If abstracts from such a diary are required as testimony, the value of such entries is greatly enhanced, the writer is told, if they are made in ink, in the handwriting of the witness, and each entry bears the date and signature when actually recorded. Inspectors should return daily reports over their signatures of the work inspected, indicating the size of gangs employed, materials used, location in work, progress made and any other information bearing on the extent or quality of the work. Some part of the engineering organization should return a daily report of the contractor's force, showing the size and occupation of each gang on the job. All entries in the field notebooks used in laying out the work should be dated, signed, and contain full information concerning who did the laying out, who requested it done, whether there was delay by either contractor or engineer in the matter, and whether the layout had been given before and lost by contractor. All such information is of much help to a lawyer and engineer in preparing a case for court.

A photographic record of construction work is of much value to an engineer, as a picture will often show at a glance what could not be recorded in several pages of written description. Photographs are often useful in refreshing the memory of an important witness, who after looking at the pictures is able to

recall all the related conditions and surroundings which otherwise would have escaped his memory. In taking photographs of work, much depends on the point of view, the source of light, the focal length of lens used and the developing and printing, whether or not the resulting picture is a fair representation of the appearance of the work at the time taken. All photographic negatives should be so marked with the serial number and date taken that the same will appear in the finished print.

Profiles and diagrams showing the weekly or monthly progress of the work are always valuable records. What the lawyers want for evidence is records that can be identified. If the engineers and inspectors would date and write their signatures on all such records as daily reports, photographic prints, progress drawings, etc., they could later go into court, if called upon, and identify such records as being the original records that they made and swear they knew that the same were true at the time they made them.

Something may occur during construction indicating that there may later be a suit involving that portion of the work then in progress. At such times outside engineers, or persons who are especially skilled in the kind of work being done, are often asked to examine the work and report on the situation as they find it, knowing that they may later be called upon to act as expert witnesses in the matter. They should be given full opportunity to make an inspection and acquaint themselves with the specifications, methods of work, materials, etc., and their reports should be made in writing, so that the lawyer preparing the case may know what to expect from such witnesses on the stand.

When maps, profiles or plans are presented in court, those drawings which are the simplest and drawn on the largest scale will be found to make the best impression on the judge or jury. Often a simple sketch of large size, freely colored up with crayons, will be just what is needed to clearly show the matter under consideration.

On the stand, after being sworn to "tell the truth, the whole truth, and nothing but the truth," the engineer soon finds out that he can tell the truth only so far as he is allowed to do so in answer to questions put to him by his or opposing counsel. Many times the lawyer on the other side will so cunningly frame a question that the witness will be unable to give a correct answer

by the demanded "yes" or "no." As the witness is not permitted to volunteer information, his examination may be concluded without his having given testimony of value to his side upon which he has fully prepared himself, because his lawyer forgot to ask him the necessary questions. For that reason some engineers who are to give expert testimony always write out a set of questions and answers, covering the technical points they are to bring out, and give a copy of same to the lawyer on their side of the case for his reference during their examination.

Many of the terms used in engineering construction have a technical or trade meaning which may not admit of exact definition, because the terms are used differently by persons in the same trade. What these words mean is often the subject of considerable inquiry in the examination of an expert witness, and it is well to be prepared on such matters, as the counsel on the other side may put many such questions, under the guise of testing his knowledge of the subject, that are really given to embarrass and confuse the witness. In general it may be said that the opposing counsel is quite willing to make the expert witness earn his fee when giving testimony, especially if what he says is damaging to the opposing side.

If the engineer presents testimony which includes his estimate of the valuation of an engineering construction or matter, he may find that such estimate is made the focus of a set of very searching questions, in which the effort is made to break down the strength of his statements. He will, no doubt, be asked to fully explain just how he made up his figures, why he placed certain values on certain parts, and if he knew, of his own knowledge, whether they were right or merely guessed at. If the engineer has analyzed his subject and prepared his estimate with care, he can generally defend his position by answers which show an intimate knowledge of the subject, and the other side is quite apt to cease questioning, especially if some of the later responses have brought out information which the other side wish concealed. If an expert is forced to say that his opinion is based in part on certain information which he has assumed, he uncovers a most vulnerable point of attack for the other side. He should be sure that the counsel on his side will establish the necessary evidence, before he gives his opinion, that will lay the substantial foundation of facts on which the opinion is based. A memorandum book of

generous size, in which the witness has set down all his computations and information, if taken on the stand and referred to, will greatly assist the witness in answering "catchy" questions. The effect of such a book on the judge or jury is not bad, also, as the witness is apparently well equipped to answer any and all questions bearing on the subject.

Every contract for engineering construction that the writer has ever read has contained the usual clause that the owner will not pay for any extras unless the same are ordered in writing by the engineer; yet suits for extras are occasionally brought and money recovered on them, notwithstanding the contract may contain the familiar clause referred to. Mention has been made that the contractors may start suit at the end of a contract covering several years' work, in which event, if they claim extras on some of the earlier work, they may have a great advantage because they collected a large amount of evidence favorable to themselves at the time the work was in progress; while the engineer, not suspecting that the contractor would sue, failed to obtain data for his side of the suit. In justice each of the contracting parties should have opportunity to collect evidence on a disputed matter.

The writer offers for your consideration a clause to be inserted in long time contracts that might obviate, in a way, the disadvantage of the engineer as mentioned in the last paragraph. The suggestion is that there be incorporated in the contract a form of declaration which the contractor shall sign before obtaining any monthly payment, in which he states that he waives the right to recover any extras except those items and amounts indicated on an itemized memorandum which he attaches and returns with the declaration to the owner.

Such a clause could form a part of the usual clause describing the monthly payments and might be worded as follows:

* * * * And before any monthly payments are made to the Contractor, he shall sign and deliver to the party of the first part the following declaration.

I hereby declare that during the month of I have not performed any work, furnished any materials, sustained any loss, delay or damage or otherwise done anything for which I shall ask, demand, sue for or claim compensation from in addition to the regular items of prices set forth in contracts or contract dated and executed between myself and

except as I hereby make claim for additional compensation as set forth on the itemized memorandum herewith attached.

(Signed)

(Date)

The writer has submitted this clause to two lawyers who have had a broad experience in engineering cases and has been assured that it is in proper form; also they think the same could be used to advantage in many long-time contracts.

Contractors would prefer contracts that did not contain such a clause, as they are forced to disclose their claims for extras at the time the work is done, if the clause appears in the contract. Still the writer thinks that on the whole such a clause would work to the mutual advantage of the engineer and contractor; misunderstandings would be threshed out at the time they first appeared and concessions would be made which would adjust many controversies. At least, any claims that remained would be in writing and the situation could be squarely faced by either party.

DISCUSSION—ENGINEER IN COURT.

I had expected up to Monday of this week to have with us this afternoon a prominent Hartford attorney who has had a great deal of experience in engineering cases, and with whom I had talked this subject over, and I wanted to call on him to explain how it is that a contractor can set up a supplementary verbal contract that is binding when the written contract has the usual clause in that "no extra work will be paid without written order of the engineer," etc., with which we probably are all of us familiar. As I recall what this lawyer says, it is that the engineer might contract as the authorized agent of the owner a verbal contract without knowing it. For instance, suppose a contractor submits some work for approval to the engineer, and should ask him: "Is that work satisfactory?" and the engineer in the presence of witnesses says, "Why, yes, that is perfectly satisfactory, and I want you to do all the rest of the work just like that." If that work is a little bit better than the contract calls for, and the contractor has the proper witnesses, etc., it might be that there was a supplementary verbal contract established at that time. I am not a lawyer and I may not have this thing just

right, but it is somewhat along those lines that verbal contracts are established.

MR. HILL: As regards the "Engineer in Court," I incline to the opinion that he would do well to keep *out* of court as much as possible. It is a fine place to waste time. But so long as this world is full of "many men of many minds" and the operators of those minds insist on looking at a thing from their own point of view, and decline to look at it from the other fellow's point of view, it will be necessary for the engineer to go into court sometimes.

I think the tendency is now for conservative engineers to counsel their clients against going to court on engineering matters. Litigation is pretty expensive; and the best service engineers can render their clients is to get the litigants together and compromise the matters, out of court, if possible. But of course that cannot always be done and the engineer gets in court. It always pays to be fair; and it never pays to exaggerate or overstate; if the engineer does that he is quite likely to get into trouble on cross-examination.

The points referred to by Mr. Brinsmade and Mr. Morton, as to preparing the case, are most important. (See p. 21.)

In very technical cases, with the average attorney who is not thoroughly familiar with technical engineering subjects, the engineer expert should write out the substance of his testimony, the points he is to testify about, make it clear and furnish his attorney a typewritten copy, so that the attorney can study it and frame his questions accurately to cover the ground. Of course when the engineer gets under cross-examination, he must answer questions responsively. He had generally best be as brief as possible and avoid "lecturing," lest his answers be suggestive to opposing counsel. The cross-examiner is likely to make it as difficult as possible for him to answer responsively without conveying wrong impressions to the Court. But in such situations, the engineer must rely much on his own attorney to clear up matters on re-direct, as his attorney will do, if he thoroughly understands the subject. Therefore the point Mr. Brinsmade makes, of preparing the case beforehand with his attorney and insisting on having time to do so, is very important.

An attorney not familiar with the engineering questions may come to you and presupposing that you have it all at your tongue's

end, ask you to take up a complicated matter and give the proper answer right offhand. I have been asked to go into court without knowing anything about what the subject was, or what I was expected to give an opinion on until in the court room. In abstruse matters, that is all wrong. It is important, for the good of the cause and for yourself, to have time to make suitable preparation. It always pays to prepare a case thoroughly beforehand.

In regard to the contractors: I think the great majority of contractors at the present day are fair, square, honorable men, who take as much interest in executing their contracts in a workmanlike and satisfactory manner, as the engineer is interested in having it done in that manner. But of course the engineer may not always have such contractors, and he cannot be too particular in noting all the facts and dates as the work progresses, so as to cover the ground, in case of trouble, as completely as possible. He need not be afraid of getting too much data.

The point Mr. Bush makes about drawings to be used in court is important. A small, beautifully executed mechanical work is not quite the thing, particularly before a jury. As Mr. Bush suggests, large scale drawings are more useful. They should be made very clear, so as to be clearly comprehended by the court. They are much more valuable than small scale, complicated drawings, for use before a jury.

Mr. Bush's paper covers a rather new and novel field. I think the suggestions he has made are excellent; and the engineer who follows them will not find himself unprepared, if he is so unfortunate as to get "in court."

MR. FURBER: Mr. President and Gentlemen, Mr. Bush showed me his paper at the annual meeting of the American Society in New York some weeks ago, and I was struck with the coincidence that I had been working along some such lines myself. I read his paper with a great deal of interest, and several thoughts occurred to me in connection therewith.

I think all the points touched upon by Mr. Bush are pertinent, as has already been said, and I shall merely discuss particularly the latter part of his paper, in which he suggests that the contractor be made to show his hand at the end of every month. I think this is a most excellent suggestion, and without casting any reflection on the contractor's integrity or his intention of doing

right, I think it is best that the work be kept up to date, as it were, every month. The only criticism I have to make of Mr. Bush's suggestion—and it is not a criticism of the idea, but more of the form—is that it might be difficult to get a contractor to sign that paper every month for fear, possibly under the advice of his lawyer, that he would be forestalling some of his subsequent rights. I think a form might be devised which would answer the purpose and possibly be a little easier of execution. It has been my practice in architectural and building work to make the contractor every month give an estimate of the amount of work that he has executed, as a basis for comparison and verification with my own estimate; and carrying Mr. Bush's thought along this line I would suggest that in the contract be put a clause in proper form to be filled out each month by the contractor, saying that "the contractor hereby certifies that he has executed such work under the terms of the contract," etc., giving all his quantities and prices, with blank lines for extra work, if any, and below that a place for his signature and affidavit. That puts the contractor on record every month, as Mr. Bush says, and if there is any difference at this time it can be taken up and settled before the contractor has been given his monthly estimate and certificate. Therefore at the time of the giving and the acceptance by the contractor of his monthly estimate, the job has been accounted for to date.

In building construction I always put a clause in the general conditions which in a measure answers the same purpose but not as completely as has been suggested. I have this clause: "If the full size or larger scale drawings show more elaborate or expensive work than the contract drawings shall provide for, notice must be given by the contractor to the architects within ten days of the receipt of the drawings in order that the drawings may be arranged and that the additional cost of such additional work may be adjusted and authorized. In the absence of such notice it is hereby agreed that the contractor accepts the drawings and will execute them without additional compensation." This is a negative way of doing the same thing that Mr. Bush has suggested be done in a positive way.

The great difficulty with laymen in points of law is to realize how easy it is to supplement a written contract, with all the formalities of a written contract, with a verbal contract that has

no formalities at all, and it takes quite a little while before a non-lawyer can get that into his head. We prepare with infinite pains a written contract, with all the conditions and contingencies likely to arise carefully provided for, which most people think is conclusive, but a little experience in court will show them that all that care, forethought and preparation can be done away with by a simple verbal agreement which has no formality whatever, between the representative parties.

Regarding the testimony of an engineer in court, this is a delicate subject to handle. When we get into court we must protect ourselves as well as protect our clients, to the extent of our ability, in whatever way may be right and in whatsoever way may occur to us as best protecting his interests.

In this connection Mr. Bush has referred to the "catch" questions which attorneys on the other side prepare to trap the expert. I would like to call the attention of the gentlemen of this meeting to a book which I came across sometime ago which is well worth the perusal of any engineer, whether intending to go into court or not. It is "Schopenhauer, on the Art of Controversy." Of course we all know Schopenhauer was a German pessimist, and being a pessimist doesn't disqualify him from giving us good advice. "In the Art of Controversy," he has put about all the possible forms which controversy may take, in about the same form that Euclid put the principles of geometry. Schopenhauer, if I remember right, has about thirty-eight propositions, and after you once have mastered the propositions as put forth by him you are able to identify and classify any form of controversy that may be put to you. Schopenhauer describes the art of controversy, not as the "art of getting at the truth" but as the "art of overcoming your antagonist."

Now be that as it may, it is, without any intention on the part of the engineer of doing his opponent any unjust harm or of taking any unjust advantage of him, just as well for the expert in court to know what the other side may do without such good intentions as he himself may possess; and by carefully studying this "Art of Controversy" you are enabled at once to "check up" the attorney on the other side and know what the particular proposition is that he is going to tackle you with and what the defense is for that proposition.

Another thing that I have discovered in my practice in court is that, as sometimes happens, after you have given your testimony, the attorney on the other side declines to cross-examine you at that time and puts it off for a subsequent hearing. This is for the purpose of enabling him to digest your testimony and have expert answers prepared to question you. I have had questions put to me under such circumstances which I could see were prepared by some one outside of the court room and given to the attorney, and possibly were questions intended to mislead and obscure the minds of the jury and put you in an unfair position; and the proper defense under such circumstances, feeling sure in your own mind that the attorney on the other side is merely giving you questions in a parrot-like form, is to profess to be unable to comprehend the question as he puts it and to make him explain his own question. Therefore you put him in exactly the position he wants to put you, and almost invariably you put him at a disadvantage.

Outside of this there are a number of points I should like to touch upon in a written discussion, which I shall endeavor to do in the near future.

MR. BUNCE: It is rather an embarrassing position to be put in to follow these gentlemen, because really they have, to my mind, covered almost all of the points that can be made. I think that you in your paper have very fully set out the engineer's part in controversy.

The trouble that I have experienced personally in court cases almost always, with one or two exceptions, has been the fact that it was almost impossible to find the attorney ready and willing sometimes to grasp the situation and to be brought into touch with the true bearing of an engineer's testimony. You touched upon that matter somewhat, and I think that part of the duty of the engineer will have to be not only to follow out the instructions which you have suggested, but also to give his attorney a pretty strong lesson and convey to his mind the fact that he must understand the testimony which you are expected to give.

I don't know, if you will pardon me, whether a little bit of experience in certainly one case will exemplify the point I make. Some years ago I was called as an expert in a case where a bridge had failed from the failure of the masonry. The masonry contract had been sublet. The specifications called for the

masonry on that bridge to be laid in first-class cement mortar. An investigation of the ruins showed plainly evidences that the contract had been shamefully neglected. Suit was brought against the sub-contractor for the failure. There were three lawyers employed by my clients, one of whom was a rough country lawyer, who examined all of what might be called the preliminary witnesses, and he did lay, I think, about the most elegant foundation for a case that I ever listened to. I think he traced every load of sand and every bag of cement on to that job, the teamster who had hauled it, and he placed the man that dug it and the man that unloaded it and where it came from and where it went. It was a splendid foundation laid. One peculiarity of the trial in this state (it was another state than this) was that of all of that class of witnesses only one was admitted to the court room at the time, so it was utterly impossible for him to hear what other witnesses had testified to and form his testimony from theirs. The second lawyer was supposed to examine the experts. The third lawyer's position in court was to be ready to answer any legal points that might be brought up by the lawyers on the other side, as the grounds for objecting to testimony, or whatever legal questions might be raised. The preliminary examination was finished. There was another engineer employed with me, and the lawyer who was to examine him commenced with his examination, and went through it, to my utter disgust. He didn't seem to apprehend what he was after, he didn't give the man a chance to tell what he knew, and in the fullest sense, to me, he was queering the case from start to finish. Fortunately that examination was in the afternoon and the court adjourned before I was called on the stand. I went to the parties who employed me and told them plainly what I thought. The lawyer who had made this examination, I found afterwards, had been retained in this case for fear he would go on the other side. I don't think he was queering the case, I don't think he knew enough to do it, but I suggested that they allow me to be examined by the strictly legal attorney, as you might designate him; and I sat down with him in the evening and went through the case with him, and wrote out a series of questions and answers. Now that was to give me the opportunity of telling what I knew about that case. That was all that was ever intended to be done. There was no intention of

putting up a job on anybody, but merely to give me a fair chance to show what I knew about it and give my opinion from my observation and from the testimony which I had heard; for one of the ways in which they examined the expert witnesses was not to put a hypothetical question, but "You have heard the testimony that has been given" (because the two experts were supposed to sit in court all the time and hear all the testimony), "You have heard all this testimony that has been given. Now based upon that, what is your opinion?" Well, I wrote out a series of questions and answers and went into court the next day, and the attorney examined me, and I thought we had made a very good presentation of the case. I really believed that the lawyers on the other side thought so, too, for when they undertook to cross-examine me they asked me three questions which had no material bearing upon the matter, and dropped me. Well, we won the case.

MR. KELLOGG: I want to say that a lawyer on the side I was to testify said before I went on the stand, that he was going to ask me a question and got my answer. He said that counsel on the other side would object, "and," says he, "I don't doubt but what the judge will rule it out, but the jury will hear it."

Speaking of drawings, makes me think of what Secretary Evarts said in a speech he made in Cooper Institute. There was an over-zealous surveyor who made a map which did his client an injury. The case was against a darkey for stealing chickens, and the map showed the chicken house, and on the corner of the chicken house he put in the words "Here is where the nigger got in."

MR. KEITH: Mr. President, I have enjoyed very much the paper that was presented, and think it is a valuable one to guide our thoughts. A few months ago I happened to be on the opposing side from our President in a case and was very much impressed with the thoroughness with which our Past President, Mr. Graves, and his assistant, now our Past President, Mr. Bush, had prepared their notes to show the work as it progressed. I never saw such thorough preparation at the time of building the work as was shown by those notes; it seemed as though they had an unlimited amount of time and were expecting that the case would go into court sometime.

There are a few things that it seems to me an engineer should always look out for. One rule that I make is never to take a side in which I do not believe; or, having taken the side tentatively, to look up the case, no matter how embarrassing it may be to drop it, if I find that I cannot support that side I will get out—I have done so several times. Some of these cases were settled out of court simply because my client became convinced of the injustice of his claim, or at least that he could not prove it satisfactorily to the Court. Once I was asked by the other side, hearing that I had given up the case, to appear for them; but that was more than I was willing to undertake. I simply drew out entirely. Withdrawal in such circumstances is prompted not simply as a matter of honesty, though that would be sufficient reason for it, but also of policy. A witness, whether an expert or other witness, who undertakes to support what he does not believe in, is pretty sure to get snarled up and do harm instead of good for his client.

It may be added that an engineer may often do as good service by arranging a reasonable compromise as by helping on a fight.

Another point. An engineer, whether he is employed to testify as to the facts or as an expert in a case, must have ample time and opportunity for the preparation; and not only that, but for consultation with the attorneys before the case comes into the courtroom.

A few years ago I was engaged in a case, being employed by the contractor, the contract amounting to about \$750,000 altogether as the estimates were made up. There was, however, a controversy on about \$250,000. At the time we began it was supposed that perhaps a thousand dollars might be required for the expenses of preparation; but before we finished over \$7,000 had been spent, for it became evident that it was not only the ignorance of the engineer for the railroad company that was at fault, but the dishonest intention of the officials, who controlled to an undue extent the actions of their engineer. The work was finished in June. The estimate for July (put in every way in the form of a final, the work being entirely completed) gave a certain amount as the estimate of the work done. We were well prepared and knew the railroad side of the case a great deal better than the railroad officials knew it; but we were surprised

to receive in October a document headed "Final Estimate," in which there was about \$150,000 increase over that which had been given in July. There was still \$100,000 in dispute, and fortunately we were able to prove our right to it sufficiently so that in a compromise about \$60,000 of that was allowed. Although the \$7,500 or so of expense in preparation was more than the contractor had anticipated, he got a very liberal allowance (over \$200,000) as a return for it, that evidently he never would have gotten if he had not prepared to fight.

With regard to the preparation—it is not only necessary that the engineer should have time to prepare, but that he should, as best he can, make the lawyer understand the engineering phases of the case, not only his own side, but that which may be presented by the other side. There needs to be a good conference between the lawyer and the engineer for the thorough preparation for the case in court. Then also, it is well at the trial, when the engineering features are under consideration, for the engineer to sit at the elbow of his lawyer ready to coach him upon any points that may come up during the examination of his own other witnesses or of the witnesses of the opposition. His advice may be needed on points that come up unexpectedly.

There is one statement of our President that I must take exception to—with regard to the catch questions that the lawyers may ask and demand that an answer be made "yes" or "no." If I understand our President right, he said that the engineer has to fail to testify to the whole truth or perhaps to testify, or appear to testify, to that which is untrue. An illustration of that sort of questions may be in place here. You have probably heard the old story about the lawyer asking a man, "Is it true that you have stopped beating your wife?" If the answer was "yes," that would indicate that the man had been in the habit of beating his wife; if he answered "no," it would appear to indicate that he was continuing to do so.

I have had a number of such questions put to me in the course of the last twenty-five years, and there is a case that comes to mind at the present time. I don't remember what the question was, but it was that sort of a question, and I answered at first "yes" (or "no," whichever it was) and started to qualify. The attorney for the opposition, who was cross-examining me, said,

"That will do, that will do; you have answered the question." I appealed to the Court for protection and the Court sustained me. In fact I have done that a number of times. The Court will not support such a trick, but will always sustain a man who is evidently intending to give honest evidence in the case.

The clause which the President has suggested for the extras seems a good one. About eight years ago I prepared specifications in which there was an attempt at the same thing, but unfortunately it was not so maturely thought out as Mr. Bush's clause; and, although the specifications called for the contractor's presenting his claim for extras each month, there were claims at the end of the contract which had not entered the mind of the contractor (I believe, though I do not pretend to be a mind reader) until after a controversy arose over another matter. It resulted in an allowance to him for extra work, which had to be acknowledged as reasonable if he wanted to be so small as to charge for it, and he chose to do so. He has more than once apologized to me since then for having made the claim; but that was after the bitterness of the controversy had subsided.

There is one more thing. I believe that the majority of contractors want to do honest work, and that with reasonable specifications they will 'do honest work. On some public work the contract has to go to the lowest bidder; but in a large part of our work an engineer or owner is allowed discretion. When a contractor is known to be in the habit of tricking his work, avoid him if it is a possible thing, even if his bid is a few dollars less than that of a man who is known to be square. It will save money in the end if you deal with a man that will do a square thing and is expecting a square return for it, rather than to feel that you are working at cross purposes, each trying to get ahead of the other all through the work. That is very expensive, not only to the contractor but also to the owner.

MR. FERRY: There is one point connected with this subject which has not been touched upon but which I think is important, and that is the interpretation of contracts. The young engineer, particularly if he is very conscientious, is liable to make the mistake of interpreting the specifications literally instead of liberally; thereby causing friction and consequent trouble with the contractor. The specifications are drawn for the protection of the owner's interests, and, of course, it is intended to cover all

possible contingencies which may arise; many of which may never occur.

The engineer who interprets his specifications literally, and insists that the contractor shall do everything exactly as the contract says it shall be done, regardless of the fact that just as good results can be obtained in some other way which will be more convenient and economical for the contractor, is sure to get into trouble. The contractor is then likely to "skin" his work as much as possible in order to get even with the engineer. The final result is likely to be a case in court.

Now, if the engineer will just look at the matter in a broad-minded way, being strict in things essential, shut his eyes to things non-essential, and help the contractor in every way he can, legitimately, there is little danger of his contracts being settled in court.

I have rarely met a contractor who did not commence his first contract with me with, as one might say, "a chip on his shoulder." Contractors are suspicious, and seem to think that you will "do" them if you can.

It has never been my misfortune to have a contract with which I have been connected taken into court. I am, however, connected with a case now in which the drawing and execution of the contract was done by another engineer. The contract was rather loosely drawn, and the engineer who drew it was asked to interpret certain clauses of the specifications. He said he drew them so that they would be "loopholes." The cross-examiner asked him what he meant by loopholes, and he answered "so that he could crawl out of the contract if he wished to." Those drawing contracts in this way are likely to find that their contracts contain pitfalls rather than loopholes.

MR. ORROK: Mr. President, I want to add just a few words to the discussion that I have heard here. I think the great trouble that engineers find in their dealings with the legal profession is the lack of knowledge of mechanics on the part of lawyers. Lawyers are taught usually in colleges, or given a classical education; then they go out in the offices and read Blackstone and Kent and several other legal authorities, and then they become lawyers. Meanwhile what little natural philosophy and mathematics they amassed in college has slipped out when the Kent and Blackstone came in, and when the engineer comes in

contact with them the first thing he has to do is to get a proper understanding of the matter in their minds. I have, in the years that I have been attending to engineering matters, a number of times had to instruct lawyers that hot air will rise and cold air will fall. I have had to instruct them that a weight placed on a platform exercised a certain pressure on the floor that holds it up; and similar matters.

As an illustration of this I want to call your attention to the decision of the Supreme Court of the United States on the 80-cent gas law. There is one clause in the opinion in which they declare the law regarding pressure to be unconstitutional because the extreme pressure of two inches and a half of water in the gas mains was liable to cause explosion in the mains. I have yet to understand how that thing passed the Supreme Court.

MR. O'CONNOR: I am not very well prepared to make a speech on this subject, but I will say this, I have heard several good arguments here in favor of arbitration. I believe that the engineers should arbitrate as well as the contractor and keep out of court. It would be better for both parties.

MR. FURBER: Mr. President, I don't like to rise twice, but several points have been brought up here in subsequent discussion about which I should like to say a word. Mr. Keith referred to the necessary and the strictest integrity on the part of the engineering expert, and I simply want to say in this connection that it only emphasizes some remarks made last night upon the extremely high ethical position that the engineer should strive to attain. As is well known to all of us, experts can be hired on legal matters, on medical matters and on chemical matters, and you can get any sort of testimony you choose to pay for. Every prominent trial that we have involving important issues, including murder trials, shows how easy it is to obtain apparently high-class testimony in diametrically opposite directions; and I think the value a competent and conscientious engineer puts on his testimony goes to show on how much higher ethical plane the engineering profession is than any other of the learned professions.

It may be said regarding the position of the lawyers that their idea may be expressed—or their attitude may be expressed, as I said Schopenhauer expressed the art of controversy, that is, as the principle of getting the best of your antagonist.

Something was said here regarding the necessity of the engineer instructing the attorney in the elementary principles of mechanics or engineering. I could say in this connection that there is a firm of attorneys in Philadelphia at the head of which is a mechanical engineer. He did not begin to study law until he was past 50, and on being questioned as to why he studied law, he said he found it very much easier to study law than to teach the lawyers engineering. The firm I refer to is one of the prominent legal firms in Philadelphia in matters pertaining to patent cases and engineering.

Another thing has been said regarding the desirability of giving a contract to a bidder who is above the lowest bidder. I think almost any man who has had any experience would discriminate in favor of a man he trusted rather than one whom he did not trust or had no knowledge of, and did not know his capacities or capabilities. But there is another side to that question. I have been up against it very frequently. For illustration, say you have asked bids on a certain proposition and the bids are opened and laid before the owners, and you express a preference for a bidder, higher than the lowest, and some such conversation as this goes on between yourself and your client: "Why should I pay more to this man than I pay the lowest man?" "Well," you say, "he is a better man, he is a man of wider experience, a man better qualified to do the work, a man in whom I have more confidence." "Well, aren't the plans and specifications complete?" You say they are. "Well, aren't the drawings complete?" "Yes, as far as they go." "Isn't everything set forth that is required to be done?" "Yes." "Well, don't I hire you to see that this is done?" It is needless to say that there is no answer to this.

MR. C. E. CHANDLER: The impression has somehow got abroad that expert testimony is liable to be biased, misleading and extravagant, to say the least. This impression was made, of course, by medical and handwriting experts.

In the neighboring states of Rhode Island, Massachusetts, and New York somehow people are coming to have a notion that engineering experts are becoming infected with the same microbe. The impression is perhaps unwarranted, but I think the danger is sufficiently great, and the matter of such importance that this association ought to establish a sort of quarantine, and prevent, if possible, the inoculation of Connecticut engineers.

Among the many humorous sayings and wise sayings of Mark Twain none, I think, is more humorous, nor more wise, nor more valuable than this: *When in doubt tell the truth.*

There is always a doubt of the advisability on the witness stand of telling anything but the truth, and obedience to the maxim will keep the engineer out of most of the pitfalls so ingeniously scattered along his path.

There are three most excellent reasons why the engineer in court should not disobey Mark Twain's injunction:

1. It is not right morally.
2. It is likely to hurt the engineer's reputation.
3. It is likely to hurt his client's case.

Some one or two, if not all three of these reasons, ought to appeal to every engineer. Of course, the engineer in court is not, from the very nature of the case, a wholly disinterested party, and even judges are considered disqualified to sit on cases in which they have any sort of personal interest, but extravagant testimony has little if any value—perhaps sometimes a negative value. Courts and committees must base their reports on the law, the evidence, and their own observation. Naturally each party puts in only the evidence they think useful to themselves. If the engineers on both sides give reasonable testimony, the decision is likely to be based on a sort of average. On the other hand, if the testimony on one side is extravagant and absurd it might best never have been given so far as its effect on the decision is concerned.

MR. BRINSMADE (by letter): The subject treated in Mr. Bush's paper is of great interest to many engineers, and their number is constantly increasing, not only due to the greater amount of contract work being done, but also due to litigation arising in condemnation cases, of which there are many, usually requiring the services of engineering experts.

Principles laid down by Mr. Bush and the excellent suggestions made by him as to the advisability of the engineer making personal notes, in his own handwriting, at the time of observations, are equally applicable in the preparation of condemnation cases.

The engineer who makes the preliminary survey for water power or domestic water supply developments will find it not only greatly to his personal advantage, but will also furnish good

foundation for expert testimony and thereby contribute to the cause of justice, and many times eliminate wrangles between the attorneys in the case, by carefully following this rule when making his observations.

In the class of cases alluded to, attorneys do not generally give the engineer sufficient notice for him to properly prepare the case. Frequently property of great value is involved and time should be given for the engineer to make all necessary observations and calculations. If engineers will insist upon having opportunity to properly investigate a case before going into court to testify, and then frankly express to the attorney for whom they are preparing the case their opinion on the engineering points, no matter if it does not exactly coincide with the attorney's preconceived notions, or of those of his client, they will have less to regret at the end of a sharp and adroit cross-examination.

MR. MORTON (by letter) : Mr. Bush in his excellent paper has called attention to the essential features in the relation of the engineer to the contractor in construction work, and his suggestions, if faithfully carried out, would result in protection to his client and fully safeguard his interests.

Reports, memoranda and good business methods, followed in the manner indicated by Mr. Bush, could not but result in a perfect organization of the engineering work and closest attention to details, which would not only protect his client in the case of future suits by the very nature of the care and business methods inaugurated, but would also result in better supervision and a clearer understanding between the engineer and contractor, and tend to promote harmony between the interests which sometimes become antagonistic. No good ever results from contentions and misunderstandings between two essential parts of the construction work; i. e., the one preparing the plans, overseeing the work and giving business supervision over the various details, and the other charged with the faithful and efficient performance of the construction. The contractor also has his troubles in reconciling the heterogeneous elements in his working force, promoting the good feeling necessary to harmonious action, as well as careful scrutiny over loose ends and waste, which often change a profitable contract into a losing one.

No set of specifications is ever so rigidly drawn or so comprehensive in its terms as to entirely cover the many unforeseen and accidental happenings in a piece of work, and it is largely dependent upon the good sense, good judgment and fair-mindedness of the engineer in charge to prevent friction, delays and unnecessary trouble when such occasion arises.

It has been the writer's fortune to have appeared more or less in court, at times representing the claimants and again the defendant. An engineer on the stand assumes to be an expert, and as such is subject to the closest examination and probing of his real knowledge by opposing counsel, and the fact that he is an expert does not carry weight with the judge, jury or commission, unless he is prepared to demonstrate in a clear and concise manner and beyond successful contradiction any statements that he may make, and his conclusions must be based upon clearly enunciated theories, substantiated by facts which can be proved and demonstrated, in order to be of value to his client. This calls for a most thorough preparation on his part. The necessity of such preparation is not always apparent to his own lawyer, and unless such preparation is allowed and proper compensation given therefor, an engineer would be unwise to go into court and submit himself to rigid cross-examination on an illy prepared case, with its consequent inadequate presentation. His own reputation will suffer thereby and he had best decline the engagement. No hearsay evidence is allowed or admitted and what someone told him is not admissible. His facts must be derived from personal experience, investigation, and from well-known authorities, or his case falls to the ground. In water power cases, which are most prolific of litigation, sometimes the question of damage is on an undeveloped water power. This involves upon the engineer complete designs and plans for a hypothetical development, which must be made in absolute fairness to both sides and upon the best possible development adaptable to the locality under consideration. It is strange to say that this plan of procedure, of such apparent necessity, is often ignored by engineers in the preparation of their testimony, with consequent weakness to their own case when the rebuttal testimony is given. Unless such plans are prepared the proper estimates of cost cannot be made, proper efficiencies used or expenditures and receipts estimated, upon which depends the feasibility and profitable character of the proposed development.

Water falling down hill does not necessarily mean that a commercially feasible development can be made. As a matter of fact, the number of water powers that are advantageously located and can be developed at a reasonable cost and for which a profitable power market can be found are few, and water powers over-capitalized and failing to come up to expectations become primarily the responsibility of the engineer if the flow of the stream or other essential features are not correctly ascertained.

Water power damage to existing enterprises, through diversion of a part or all of the stream flow for water supply or other purposes, can be made theoretically to show up large damages, sometimes beyond the total value of the entire property, but such figures are misleading, capable of successful criticism and do not produce big awards for the engineer's clients. There are many features entering into the practical operation of the plant which the engineer must take into account. Water powers cannot be produced and cannot be operated without cost. Allowances must be made for a reasonable interest on the construction cost, depreciation of the structures and machinery, repair account, labor account and general expense account, and when all these have been figured it sometimes will be found that the margin in favor of the water power as against the production of the same power by other means is not nearly so large as popular opinion would have it, and yet this comparison generally measures the value of the water power to the owner thereof, or the amount of damage in the case of diversion of a part of the stream flow.

Water powers have made great strides in the past few years, due to the electrical transmission of the power derived therefrom, but it also must be borne in mind that the art of steam engineering has also advanced rapidly and the production of power in large units reduces the cost to very small figures per horse power. The centralizing of power and the enormous growth in the use of electricity which has caused this has carried with it an increasing number of bright, intelligent, specialized engineers, which has resulted not only in decreased coal consumption, but in increased efficiency of management and extension of power uses, all of which has materially reduced the manufacturing cost of power. It is, then, of primary importance that the engineer, posing in court as an expert, must be well informed on all these matters, must have his information in available shape, present his state-

ments clearly and understandingly, and as free as possible from technical phrases and to the full understanding of the layman mind. The writer would say without hesitation that, conceding the engineer of proper experience and knowledge of his subject, the complete preparation of his case is the essential feature and the one most likely to convince others of his own earnest and sincere beliefs. Next to this, probably, would be the element of fairness with which he handles the subject and the avoidance of any appearance of bias in favor of his clients.

CONSERVATION IN THE USE OF WOOD.

By H. S. Betts, United States Forest Service.

The amount of wood cut in this country in 1907, including waste in logging and manufacture, reached a total of some 23 billion cubic feet. This gives a per capita consumption of about 260 cubic feet. In comparison with the per capita consumption of Germany, which was about 37 cubic feet, our prodigality in



FIG. 1. CREOSOTED BRIDGE STRINGER UNDER TEST.
First and second failures in compression.

the matter of using wood is very evident. It would seem, therefore, that this difference in consumption ought to be susceptible of a considerable decrease without necessitating excessive economy.

The principal causes of lumber waste in this country are fire, wasteful methods of logging and turpentining, waste in the mill and waste in the use of wood.

In addition to the tremendous loss in commercial timber by fire, amounting to \$50,000,000 annually, the same cause destroys young growth, renders the streams less navigable and causes the character of the succeeding growth to deteriorate.

The waste in logging, due to leaving merchantable trees in the woods, to cutting high stumps and long tops, to breakage in felling and to the use of good timber for temporary structures in logging operations, amount to about 25 per cent. or 1,000 board feet out of every 4,000 feet logged.

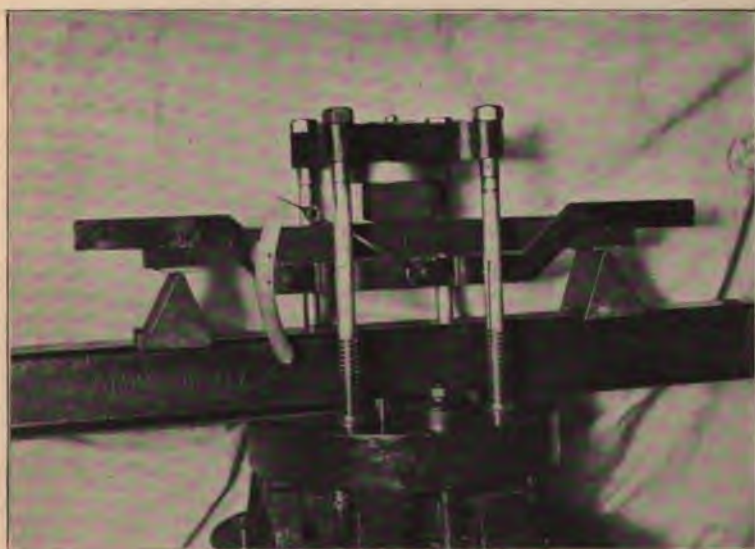


FIG. 2. BENDING TEST ON SMALL SPECIMEN.
(2" x 2" x 30".)

The methods of turpentining at present in vogue in the southeastern states generally render the forests unproductive in from three to five years, when it is abandoned to the ravages of fire, to which the trees are particularly susceptible on account of the inflammable nature of the resinous faces. Unless logging follows soon after turpentining, a large percentage of the boxed trees becomes so weakened by fire and insects as to cause many to be blown down and lost. One-fifth of the forests worked have been thus destroyed.

In the mill about one-third of the log goes into saw kerf, edgings, trimmings and slabs. Part of this loss is, of course, unavoidable under the present methods.

In investigating the loss incident to the use of sawed lumber, it is difficult to estimate closely. In the building trades, which consumed in 1907 about 60 per cent. of the sawed lumber used in this country, the loss due to seasoning, eliminating defects and fitting to final form, was not less than 15 per cent. Furniture factories show a similar loss of 30 per cent. and box factories

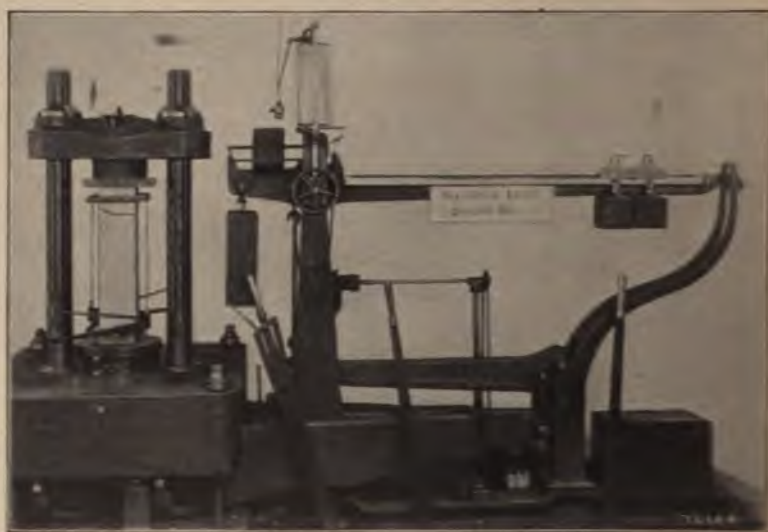


FIG. 3. COMPRESSION TEST ON SHORT COLUMNS.
Note wrinkle near top where failure has occurred.

a loss of 20 per cent. Reports from a number of railroads indicate a loss of 10 per cent. in the use of sawed lumber, while vehicle and implement manufacturers lost about 25 per cent. This gives an average waste of 17 per cent. in the use of sawed timber, made up mostly of sawdust, shavings and small blocks, nearly all of which is burned under the factory boilers or used for kindling wood, so that it can not be considered a total waste.

Out of the total cut for 1907, some 40 billion board feet went into sawed lumber, and of this about two-fifths was structural

material, such as scantling, joist, dimension and bridge timbers. Packing boxes, implements and vehicles take another fifth, and of the material not used in the form of sawed lumber, hewed railroad ties, telephone poles and mine timbers made up a very large part. In all these uses the fitness of the material depends upon such qualities as strength, stiffness, hardness, durability, or adaptability to preservative treatment, as the case may be, so that a knowledge of such properties for the various species of wood become essential to their most economical use.

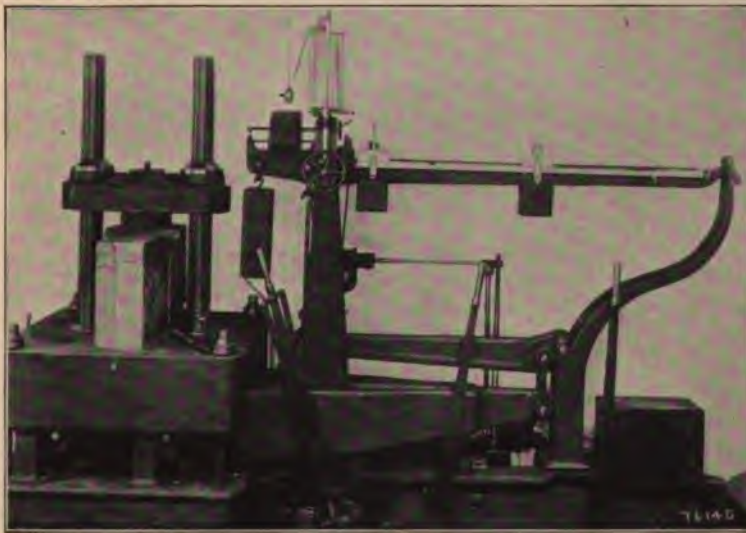


FIG. 4. COMPRESSION TEST AT RIGHT ANGLES TO GRAIN,
Similar to action of rail on tie.

When the lumber industry first took its place as one of the principal industries of the country, the center of production was in the New England states; from there it shifted to the lake states, and then to the southeastern states, where it was in 1907 and where it will probably stay for a few years longer. The next move will be to the northwest. Meanwhile, the price of lumber has been steadily advancing, and this fact, taken in connection with the introduction of new species and lower grades, which naturally go with an increase in price, has caused more attention to be paid of late to the economical use of wood than in the past.

When wood was more plentiful than it is now and the cost of manufacturing, as compared to the cost of stumpage, was considerably higher than at present, it was often cheaper to use structural material in much larger sizes than necessary rather than go to the expense of sawing it to smaller sizes. But such conditions have undergone a change and the tendency is now to use structural lumber heavy enough to do the work safely and no more. This situation naturally calls for accurate and authentic data on the mechanical properties of wood used in structural operations.

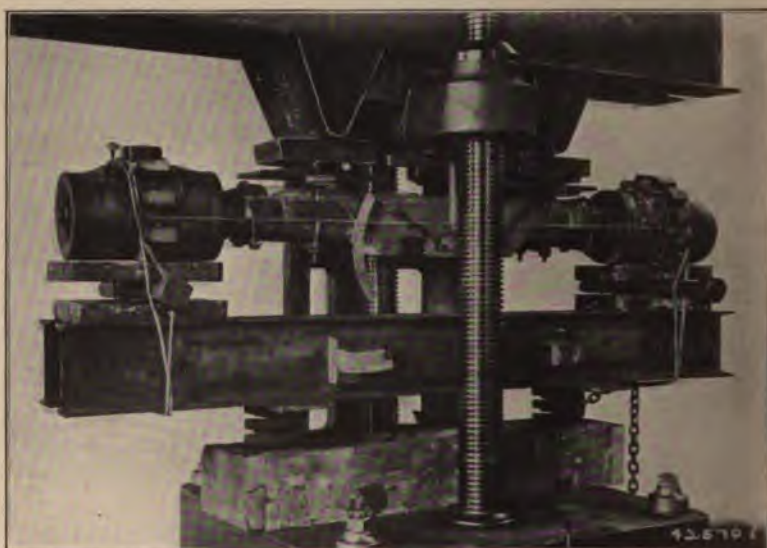


FIG. 5. TESTING A WAGON AXLE.
Conditions of actual use reproduced.

The preservation of timber by the use of creosote or zinc chloride has made a rapid advance in the past few years. Here again it becomes necessary to carefully investigate the mechanical properties of the timber after it has been subjected to the various treatments in vogue. It may be advisable to increase the life by preservative processes at the expense of the strength and stiffness of the timber, but in any case the effect of the preserving methods in vogue should be known, so that allowance can be made in the design of the structure under consideration.

The main purpose of one of the divisions of the Forest Service is to furnish information that will aid in a closer utilization of forest products. Investigations for the purpose of securing such information are conducted along three general lines: Timber tests, wood preservation, and wood chemistry. Timber tests are carried on in laboratories at several points throughout the country, generally in coöperation with some large university. At present the Service has laboratories at San Francisco, Cal., Seattle, Wash., Boulder, Colo., Lafayette, Ind., and New Haven, Conn. These laboratories are equipped with testing machines,

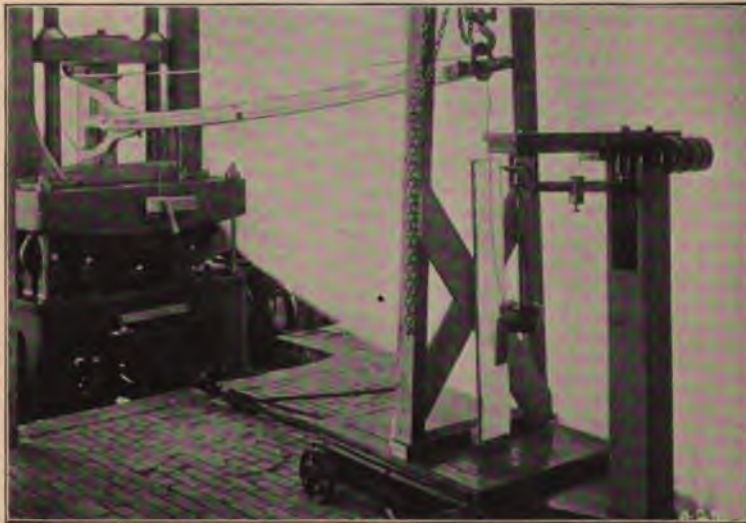


FIG. 6. WAGON POLE UNDER TEST.

generally of the Olsen or Riehle type, suitable for making bending or compression tests on timber in large or small sizes, and some have, in addition, impact, torsion and abrasion machines. Most of the material tested is furnished by parties interested in the results, generally through the medium of associations.

During the past few years tests have been made on a number of species of structural timber, including Douglas fir, tamarack, longleaf pine, loblolly pine and western hemlock. Tests have also been made on vehicle parts, such as axles, spokes, poles and shafts; on packing boxes and various other special forms. Tests

are at present under way on redwood, western larch, tanbark oak, hickory, and on the California eucalyptus. The Service is also investigating the relative strength of treated and untreated southern pine bridge stringers, and conducting a number of special investigations on the behavior of wood when seasoned by different methods. Reports on the results of the investigations

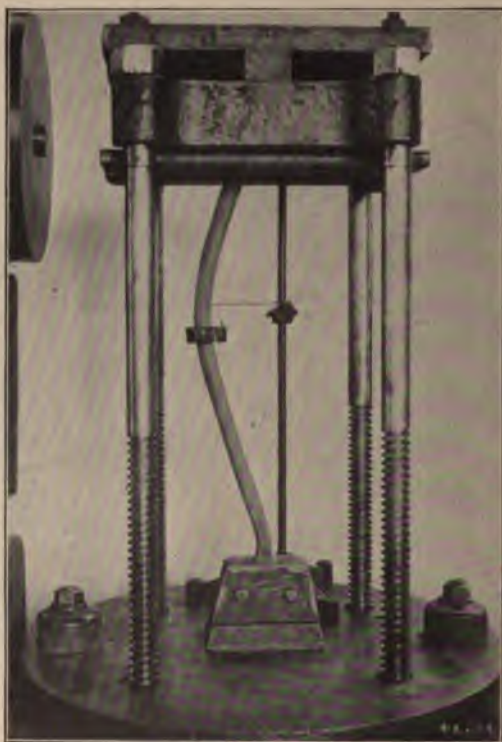


FIG. 7. HICKORY BUGGY SPOKE UNDER TEST.

are published from time to time in circular form. The associations coöperating in the various lines of work are furnished with monthly progress reports.

The preservation of wood by the injection of chemicals has made it possible, in a number of cases, to substitute the cheap, abundant woods for those of higher quality. It has made available a new source of supply, decreasing the drain on valuable

woods and decreasing the demands on standing timber by permitting of less frequent renewals. By introducing the open-tank treatment the Service has brought wood preservation within the reach of the farmer and the man of limited means, and shown how cheap apparatus and methods can be used to good advantage.

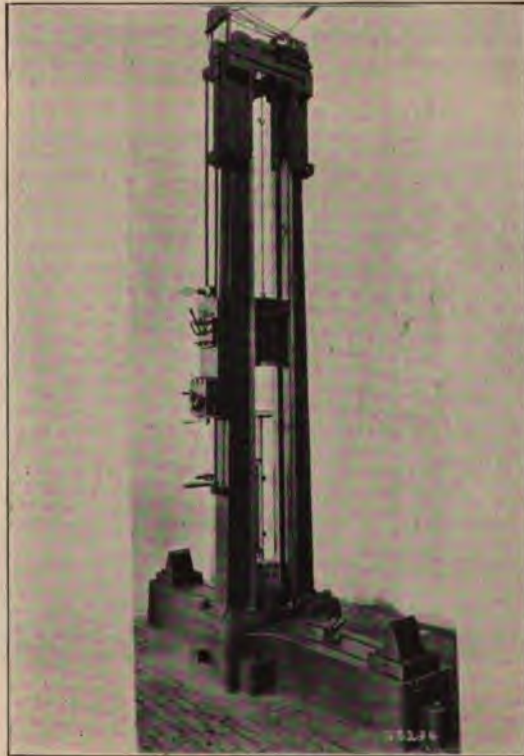


FIG. 8. MACHINE FOR MAKING IMPACT TESTS.

Such work is generally carried on in coöperation with state agricultural institutions. In coöperation with large consumers, such as telephone, mining, railroad, lumber and traction companies, the Service has been able to give considerable help in the design, construction and experimental operations of treating plants. Small plants have been built in the National Forests in Colorado and South Dakota to treat dead timber. This timber

is now being disposed of and the land rapidly cleared so that it can be reforested.

During the coming summer the Service hopes to equip and install an experimental wood preservation laboratory. Part of the apparatus for this laboratory has already been built and the rest is under construction.

For the past three years a small experimental pulp laboratory has been maintained for the purpose of investigating the suitability for pulp of woods not now used for this purpose and

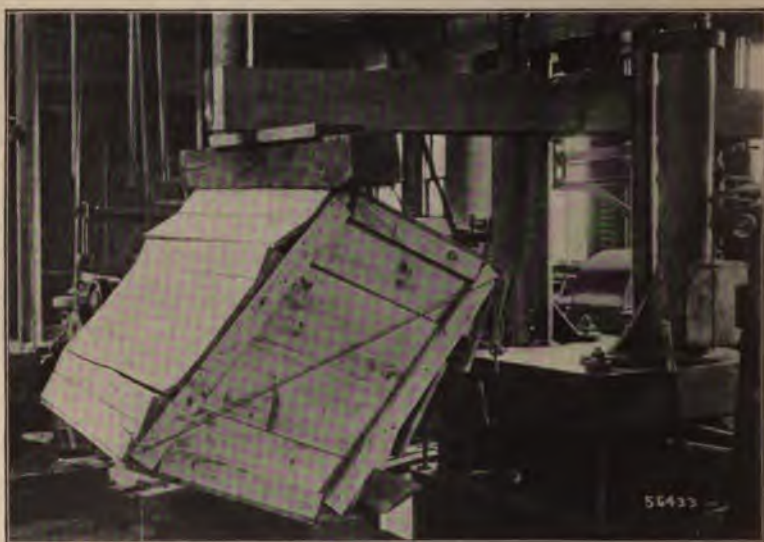


FIG. 9. PACKING BOX UNDER TEST, SHOWING MANNER OF FAILURE.

which are not especially valuable for lumber. Several western woods, not of high value for lumber, have been proved to make good commercial grades of pulp by the ordinary sulphite process. Among these are white fir, lowland fir, Engelmann spruce and lodgepole pine. The white fir yields a pulp equally as valuable as that obtained from the eastern spruce. Several eastern woods which are not used to a large extent for either lumber or pulp have proved capable of furnishing grades of pulp suitable for wrapping papers and similar uses. Among these are scrub pine and tupelo gum. Experiments are greatly needed

to show what results may be expected from the utilization of waste in logging and mill operations for pulp material. Preliminary tests have been made in coöperation with the Bureau of Plant Industry to determine the possibility of making pulp from fibers other than wood. A number of tests have been made on cornstalks, and some on cotton stalks and rice straw. The results are such as to warrant a more careful study of the possibility of using these and other classes of fiber. The work of the pulp laboratory offers a means of lessening the demands on

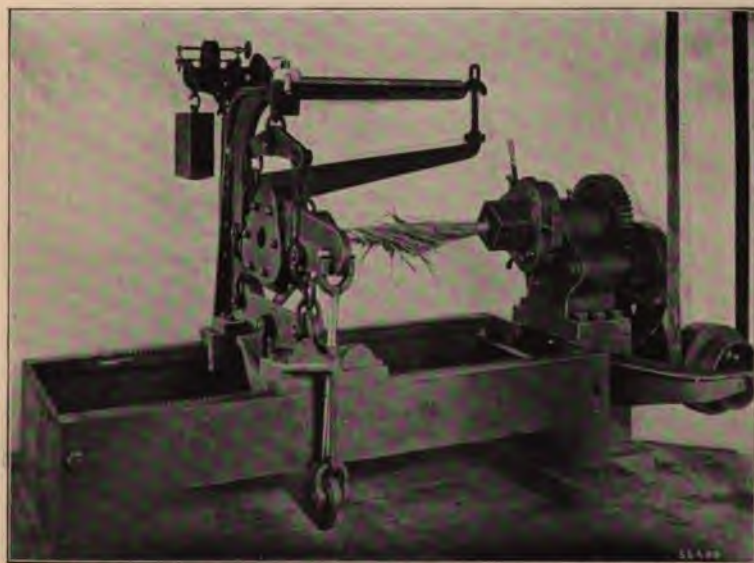


FIG. 10. TORSION TEST ON HICKORY.

valuable woods of limited quantity by bringing into use species now of little commercial value, of saving a large amount of inevitable waste in lumbering and sawmill operations; also of opening up a new source of supply for pulp from waste farm materials.

Distillation offers another means of utilizing the present waste in logging, mill and manufacturing operations. In this process such products as wood turpentine, wood alcohol, acetate of lime, charcoal and tar are recovered. A number of plants have been started in the southern states in connection with sawmills, but

on account of present low price of turpentine, a number of them have been discontinued as unprofitable from a business standpoint. Nevertheless, it seems merely a matter of time when operations of this character will be conducted much more extensively. The Service has just finished the construction of a special type of still for investigating the quality of turpentine produced by different methods, and it is thought that investigations conducted with it will be of assistance in settling many disputed questions concerning the worth of wood turpentine.

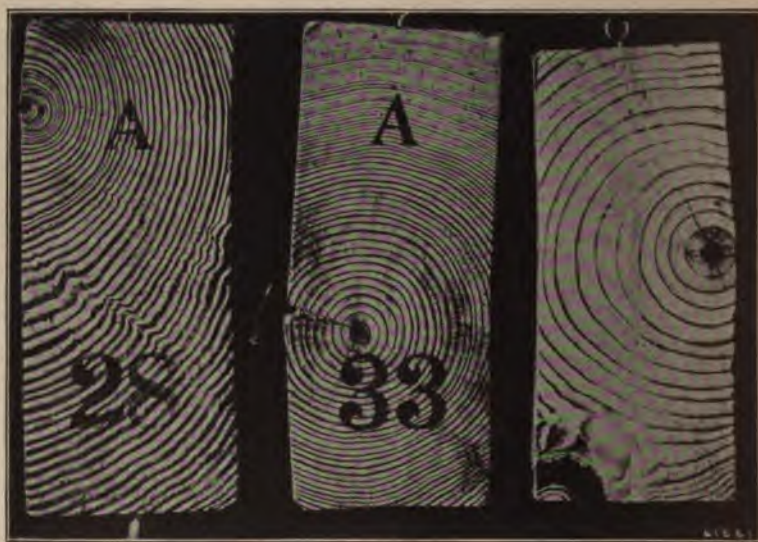


FIG. 11. SECTIONS CUT FROM 5" X 12" X 16' STICKS OF LOBLOLLY PINE, SHOWING RANGE IN RATE OF GROWTH AND PROPORTION OF SUMMER WOOD.

It is the intention of the Service some time during the present year to consolidate its laboratories in the eastern United States into one central laboratory, to be located at some large university in the vicinity of Chicago. This laboratory will include work in wood preservation, timber tests, wood pulp and wood distillation, and it will be the earnest endeavor of its staff to furnish information which will be of practical use in decreasing the present waste in the use of timber.

In investigating the effects of knots and cross grain on beams, it was found that, when these defects occur near the bottom or

tension face, failure is nearly always due to their presence. When the tension face is free from defects, and knots occur on the top or compression face, the beams will fail first in compression. When both tension and compression faces are clear, defects occurring in other parts of the beam have little influence on its strength. The results of a series of tests on 5" x 12" x 16' loblolly pine beams show that those containing knots in the middle half within a couple of inches of the top or bottom face, have about 75 per cent. of the strength of beams clear in the same portions.

Shakes and seasoning checks operate to divide a beam into two parts, and cause it to fail by what is called horizontal shear; that is, splitting from the end toward the middle rather than by tearing apart in tension at the middle.

The most common shake is a ring shake, which is a separation of the stick between two annual rings. It is a common belief that such shakes are caused by the action of the wind in swaying the tree from side to side, although the correctness of this view has never been proven.

Seasoning checks are caused by strains arising from unequal shrinkage. The end of a stick generally checks along the planes of the radial fiber. When the stick is dried, its ends shrink before the drying action reaches the interior of the stick and thus tend to become smaller, while the cross section nearer the middle is still of its original size. The fibers at the ends of the stick are bent in, until the strain becomes so great that they separate and return to their original position, checks being opened up in the process. Practically the same thing happens when the stick checks along its sides.

A series of tests was carried out at the Forest Service laboratories on vehicle woods, including maple and hickory axles; southern pine, Douglas fir and oak poles; hickory and oak shafts, and hickory spokes. In making tests of this character on material in finished form, the test rigging was, whenever possible, arranged to reproduce the conditions which the specimens would meet with in actual service. These tests were made with the object of investigating the correctness of some of the present grading rules for vehicle stock, and of comparing the properties of standard woods and possible substitutes. It was found that the prejudice against red hickory spokes was unfounded, and that

many spokes now thrown into the lower grades on account of their red color should, from their strength and toughness, be placed in higher grades. In view of the results of these tests, a committee, representing a large part of the vehicle manufacturers of the country, has recently recommended that the present grading rules for vehicle stock be revised and red hickory material be given its proper place.

On account of the scarcity of hickory, numerous attempts have been made to find a wood that could be used in its place. It is probable that no species, growing in commercial quantities in the United States, possesses the qualities of strength and toughness to the same degree as hickory. California eucalyptus comes nearest to hickory in mechanical properties, but it is difficult to dry without warping and checking. These difficulties can, however, probably be overcome with the proper system of drying.

Impact tests have been made on a number of woods to find their ability to resist failure under repeated loads. In making these tests, the specimen is generally in the form of a small stick about 2" square and 30" long. It is supported at the ends and a weight, sliding between vertical, fixed supports, is allowed to fall on it from increasing heights until it breaks. A pencil is attached to the weight, or hammer, and arranged to bear against a revolving drum, covered with sensitized paper. When the weight falls, this pencil makes a record of the deflection of the stick under the blow, and also shows the height of the rebound. Beams tested under such conditions of rapidly applied load will bend twice as much and stand twice as much stress before the elastic limit is reached as when tested under ordinary static loading.

The spike-holding power of a number of woods has been tested. The spikes were driven into railroad ties and pulled out by means of a testing machine. The screw spike, common in European railroads and used to some extent in the United States, was found to have about twice the holding power of the common spike. White oak had the greatest holding power of the species tested.

A series of tests was made on wooden packing boxes. Several species were used, and various forms of battens were tried. A stronger box is made by driving most of the nails through the ends of the side, top, and bottom boards into the end boards rather than into the battens. Cottonwood and red gum made the

strongest boxes. The other species tested were loblolly pine, western spruce, western hemlock and white pine.

The influence of moisture on a number of species was thoroughly investigated. It was found that small, clear, green pieces could be increased in strength about three times by being carefully dried. This increase in strength does not, however, occur in the case of structural timber dried out from a green state, except to a limited degree. As structural timber is commonly handled, the drying process induces defects, such as checks and shakes, which tend to offset any increase in strength in the wood fiber due to drying, and to render the piece as a whole little if any stronger than when green.

In the case of a series of tests made on green and seasoned shortleaf pine, an increase in strength of some 20 per cent. of the seasoned material over the green was noted. These sticks were, however, seasoned with unusual care, and in a majority of cases, it is not safe to count on an increase in strength due to seasoning structural material.

Tests are now in progress on tanbark oak, the eucalyptus, several species of hickory and western larch. Tanbark oak is a California wood, cut almost entirely from its bark, and generally left on the ground to decay unless it can be used as fuel. It is much too valuable a wood to be allowed to go to waste in this way, especially in view of the scarcity of hardwoods in California.

The trunk of a tree is made up of concentric layers of annual growth. Each layer consists of two bands, one of dense, dark material (summerwood), and one of more porous, lighter colored material (springwood). The summerwood is much stronger and heavier than the springwood. On this account, the weight and strength of wood depends largely upon the proportion of summerwood in the annual rings. In general, the strength of various species varies directly with the weight, although there are exceptions to this rule. Fast-growing woods are generally considered weak, but this does not always hold true, as shown in the case of sapling hickory and second-growth red oak, both of which are exceptionally strong and tough.

In investigating the effect of rate of growth on the strength of wood used for structural purposes, it was found that as a general rule the strength and specific gravity increase in a fairly

uniform manner with the number of rings per inch, until a point is reached corresponding to the maximum vigor in the growth of the tree, where the annual rings have their largest proportion of summerwood; after this the strength decreases with the increasing fineness of the rings put on by the tree in its old age. In the case of Douglas fir, the strength increases with the rings per inch up to about eighteen rings; after that the strength falls off.

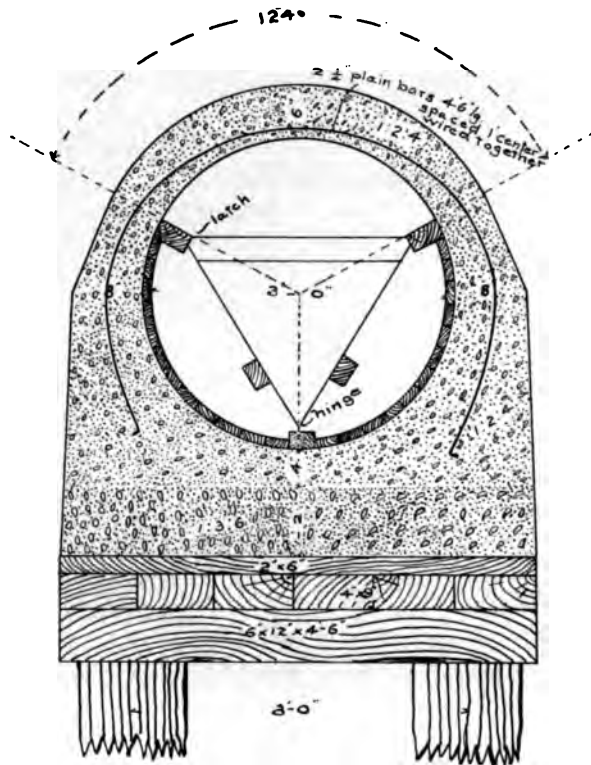
The sapwood of a tree includes the outer portion of the trunk, and forms a passage for the transportation of the food supply between the roots and the crown. Inside of the sapwood is the heartwood, which contains no living tissue. The heartwood is generally darker in color than the sapwood, but the per cent. of moisture in the sapwood is much larger than in the heartwood. As a rule, the heartwood of a log cut from a mature tree is stronger and heavier than the sapwood. The reason for this is that the rings in the heart were formed when the tree was young and vigorous. The change from heart to sap, in itself, has no influence on the strength. The sapwood of a log, which generally represents the growth of the tree during its old age, is weaker and lighter, on account of its period of formation and not because it is sapwood.

SOME NOTES ON THE COST OF CON- STRUCTING SEWERS.

By J. Frederick Jackson, Mem. Conn. Soc. C. E.

The keeping of cost accounts is undoubtedly very helpful to the engineer, who has had particular charge of the work under consideration, and who is able to bring to the analysis other knowledge than that of the figures involved. The study of the figures will be helpful to any engineer who may desire to get a line on the same class of work; but he will need to consider conditions, which perhaps do not show in the cost account and on which each one must put his own value. If there were some uniform method of reporting costs it might be possible to compare and analyze the work in different localities, but to devise a form which would take account of factors which can not be expressed mathematically and on which each one must put his own value, is quite a problem. It is very difficult, unless one is working with and under a system prepared in advance, to obtain the actual distribution of cost on any work, and this is especially so on the sewer work here described, where the sizes in most of the contracts vary and where the gangs are so organized, or rather disorganized, that part of one may be working on one section one hour and the next on an entirely different one. These notes, therefore, in some instances may not be as clear as desired, but on the whole the distribution is fairly accurate. I have not reduced the cost to units in these notes, leaving it to each one to make his own analysis, after stating conditions, quantities and costs as clearly as possible.

The first piece of work described consists of 676 feet of 36-inch reinforced concrete sewer on pile and timber foundation, as shown in section. It was built across meadow land and had 4 manholes; the concrete was 1:3:6 for the foundation and 1:2:4 for the remainder.



5 cubic feet 1:3:6 concrete, per lineal foot.
 8½ cubic feet 1:2:4 " " " "
 6½ feet B. M. 12" timber per lineal foot.
 18 " " 4" " " " "
 9 " " 2" " " " "
 ½ pile,
 2 ½ plain bars 4'-6" long.
 3-9" spikes.
 6-5" "

The account was :

PILING.

24	days foreman	cost	\$120.00
24	" engineer	"	106.00
73	" labor	"	160.00

CONCRETE.

82.5	days labor on 1:3:6	cost	\$154.65
82.5	" superintendence, 1:3:6	"	632.00
61.5	" labor, invert 1:2:4	"	116.00

125.5	days	superintendence, 1:2:4	cost	\$676.00
58.9	"	labor arch, 1:2:4	"	113.74
117.8	"	arch superintendence, 1:2:4	"	648.00
6	"	labor, manholes	"	16.50
6	"	superintendence	"	33.00

The high value of the item of superintendence is due to both members of the firm's time being included..

MATERIALS.

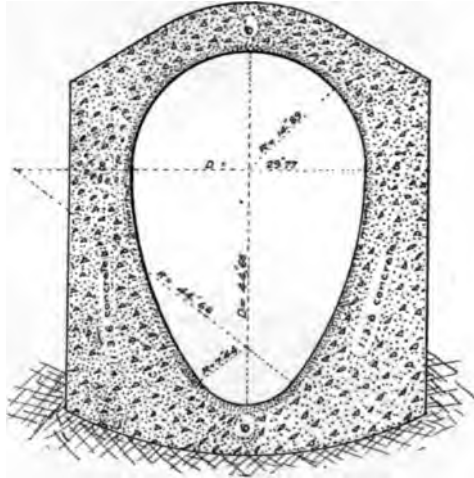
1:3:6	162	bbls. cement	cost	\$226.80
	1,944	cubic feet sand	"	39.00
	3,888	cubic feet stone	"	262.00
1:2:4	invert			
	178	bbls. cement	"	249.20
	1,426	cubic feet sand	"	28.50
	2,858	cubic feet stone	"	191.50
1:2:4	arch			
	115	bbls. cement	"	161.00
	920	cubic feet sand	"	18.40
	1,840	cubic feet stone	"	122.28
	1,807	lbs. ¼ inch steel bars	"	72.25
	2	arch forms 8 feet long	"	14.75
	1	manhole form	"	40.00
		Screeds and outside forms	"	120.00

The second piece had 1,801.4 feet of 36-inch egg-shaped concrete sewer on timber cradle as shown in section, average cut 13 feet, through sand and gravel with some water at the start; 62 feet of 36-inch brick curve average cut 14 feet; 8 catch basins, 11 manholes. A 300-foot cable was used for the excavation. The concrete was 1:3:6 for the foundation and 1:2:4 for the remainder. It was mixed and placed by hand, chutes being used to deposit it in the ditch, sand and gravel for the concrete was obtained on the work.

The account was:

260	days	labor	mixing concrete	}	cost \$ 741.52
109	"	"	placing "		
71	"	"	tamping "		
959	"	"	excavation	"	1,737.88
402	"	"	backfilling	"	601.00
208	"	"	sheathing and bracing	"	375.76
286.5	"	"	screening gravel	"	504.83
93.3	"	"	moving and setting up forms	"	168.92
24.8	"	"	hauling surplus	"	140.30
63.8	"	"	moving engine and cable	"	212.84
52.5	"	"	cleaning and patching forms	"	114.44

Watchmen	cost \$	42.00
831 bbls. cement	"	1,371.15
236 cubic yards sand	"	71.00
471.5 cubic yards gravel	"	504.00
19.5 tons coal	"	98.00
Rental of forms	"	390.00



$\frac{1}{2}$ cubic yard concrete per lineal foot.

The following are examples of brick and concrete combined. In the first there were 907 feet of 43-inch rectangular section on pile and timber, average cut 7 feet through filling mud and water; 19 feet of same section on grillage, average cut 8.5 feet; 65 feet 36-inch brick, average cut 9 feet through sand, gravel and water; 55 feet 24-inch 8-inch work through same material, average cut 8 feet; 98 feet 24-inch 8-inch invert, through same material; 100 feet 10-inch pipe culvert, 8 manholes, 1 dolphin.

The account was:

PILING.

31 days foreman	cost \$	108.50
189 " labor	"	378.00
485 piles	"	1,018.00

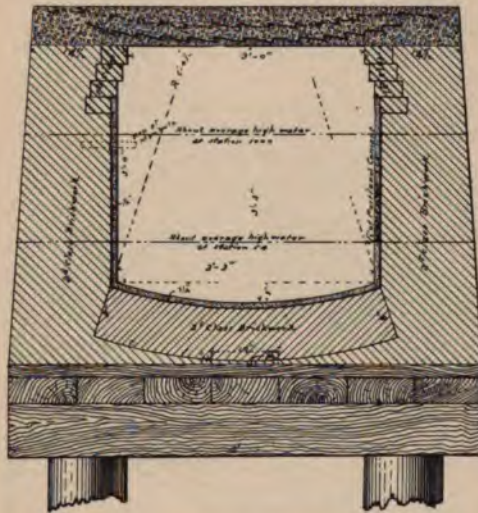
43-INCH SECTION.

121 days mason	cost \$	544.00
81 " foreman	"	162.00
1,429 " labor	"	2,341.00

89	days team	cost \$	378.00
42	M No. 1 brick	"	336.00
179.5	M No. 2 brick	"	458.00
576	bbls. Portland cement	"	1,152.00
245	bbls. Rosendale "	"	245.00
230	tons crushed stone	"	230.00
47	M feet B. M. timber	"	1,142.00
5,200	lbs. expanded metal	"	208.00
	Canvas and rubber boots	"	90.00
	Dowels and spikes	"	68.00
	Sawing off piles	"	42.50

36-INCH, 24-INCH, 30-INCH SECTIONS.

26	days mason	cost	\$113.85
13	" foreman	"	25.80
114	" labor	"	200.00



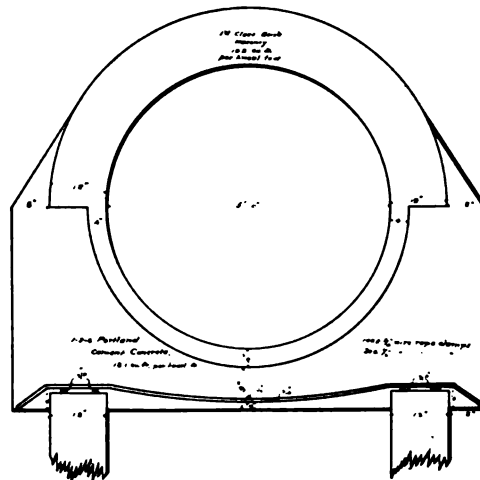
12 feet B. M. 2" spruce, per lineal foot.
 24 feet " 4" yellow pine planed one side.
 12 feet " 8" x 12" yellow pine.
 12 cubic feet 2nd class brick work.
 2.7 cubic feet 1: 2: 4 concrete.
 4 square feet expanded metal.
 9.5 square feet plaster $\frac{1}{2}$ " and $\frac{3}{4}$ " thick.
 $\frac{1}{2}$ pile.

The second consisted of 276 feet of 60-inch circular brick sewer on piles as shown on accompanying cut; it was in cut and fill, through old filling, mud and water; 105 feet of 60-inch with

haunch walls, average cut 9.5 feet through sand, filling and water; 27 feet of 18-inch vitrified pipe, average cut 11 feet through sand, filling and water; 52.6 feet of 12-inch vitrified pipe, average cut 9.5 feet through same material; 54 feet of 10-inch pipe culvert; 11 feet 12-inch pipe culvert; 3 catch basins, 3 manholes.

The account was:

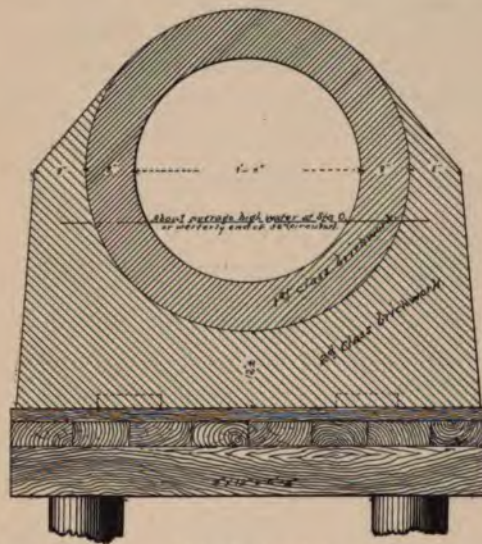
80	days mason	cost \$	442.00
126	" concrete labor	"	220.00
126	" placing steel	"	220.00
93	" excavation labor	"	1,391.50
75	" backfilling "	"	112.50
32	" sheeting trench	"	58.50
22	" forms sheeting	"	38.50
296	bbls. Portland cement	"	660.00
263	bbls. Rosendale "	"	263.00
116	cubic yards sand	"	87.00
231	cubic yards stone	"	345.00
114.5	M brick	"	1,145.00
171	piles	"	600.00



60 inch circular.

These are some examples of brick sewers. The first had 60 feet of 36-inch circular brick sewer with haunch walls on piles and timber foundation, in water; 40.2 feet 36-inch circular on grillage, average cut 7.5 feet through sand and water; 555 feet

36-inch egg-shaped, average cut 11 feet through sand, some water at start; 1,238.2 feet 30-inch circular, average cut 13.7 feet through sand; 5,566 feet 24-inch egg-shaped, average cut 13.7 feet through sand; 177 feet 18-inch vitrified pipe, average cut 13 feet through sand; 313.8 feet 15-inch vitrified pipe, average cut 12 feet through sand; 292 feet 10-inch pipe culvert; 20 catch basins, 28 manholes, 17,630 feet B. M. timber, 60 cubic yards rip-rap, 13 cubic yards concrete, 40 piles.



36-inch circular.

7.7 cubic feet 1st class brick masonry, per lineal foot.
 12.3 cubic feet 2d " " " " "
 18 feet B. M. 2" spruce timber, " " "
 35.5 feet " 4" " " " "
 13 feet " 8" x 12" yellow pine timber, per lineal foot.
 $\frac{1}{2}$ pile.

The account was:

36-INCH CIRCULAR.

19	days mason	cost	\$ 83.19
88	" labor	"	141.81
4.5	" team	"	22.50
16	M No. 1 brick	"	160.00
20	M No. 2 brick	"	100.00
40	bbls. Portland cement	"	100.00
6	tons crushed stone	"	6.16

40	piles	cost	\$200.00
6,650	feet B.M. timber	"	167.35
	Spikes	"	10.00

36-INCH EGG-SHAPED.

53	days mason	cost	\$ 233.20
10	" foreman	"	36.00
398	" labor	"	624.00
16.5	" team	"	80.50
100	M brick	"	1,000.00
194	bbls. cement	"	194.00

30-INCH EGG-SHAPED.

92.75	days mason	cost	\$ 408.10
21.75	" foreman	"	41.60
768.4	" labor	"	1,280.69
32	" team	"	233.00
126	M brick	"	1,260.00
257	bbls. Rosendale cement	"	257.00
	Timber	"	190.90

24-INCH EGG-SHAPED.

41	days mason	cost	\$301.40
8	" foreman	"	16.00
351.75	" labor	"	441.77
18.5	" team	"	78.00
38	M brick	"	380.00
102	bbls. Rosendale cement	"	102.00

18-INCH, 15-INCH, 12-INCH VITRIFIED PIPE, CATCH BASINS, ETC.

33.5	days mason	cost	\$ 366.30
34	" foreman	"	68.00
565	" labor	"	1,094.00
33.5	" team	"	143.50
81	M brick	"	810.00
201	bbls. Rosendale cement	"	201.00

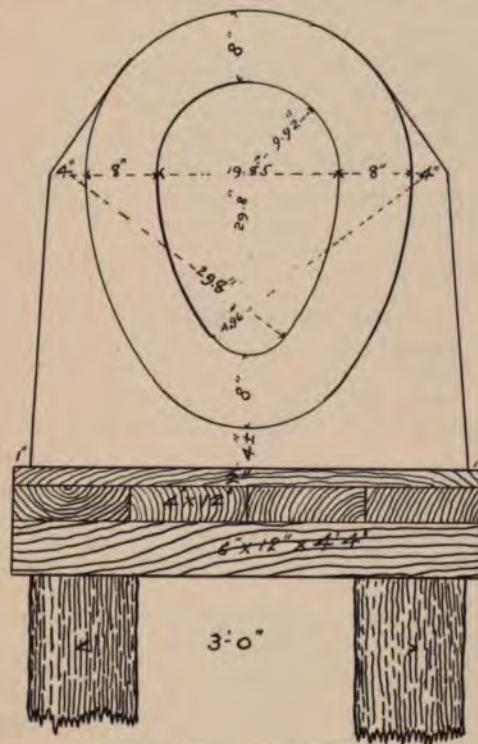
The second consisted of 515 feet 30-inch egg-shaped sewer, average cut 14.8 feet through sand; 468.6 feet 24-inch, average cut 14.3 feet through sand; 16 feet of 15-inch vitrified pipe sewer, average cut 13.5 feet through sand; 203 feet 10-inch pipe culvert; 5 catch basins, 6 manholes. It was built in a street which had a double-track car line, traffic on one of which could not be interrupted.

The account was:

69	days mason	cost \$	414.00
32	" foreman	"	64.00
747	" labor	"	1,364.00
111	M brick	"	1,003.00
255	bbls. cement	"	255.00
7,915	feet B.M. timber	"	200.00

The two following have some points of similarity and, as will be readily seen, offer several items for comparison.

The first had 118.7 feet of 24-inch egg-shaped sewer, on pile and timber foundation, as shown in accompanying section, which applies to both, average cut 8 feet through mud and water;



24-inch egg-shaped.

5.7	cubic feet 1st class brick masonry, per lineal foot,		
6.5	cubic feet 2nd " " "		
6.5	feet B. M. 12" timber,		
17.3	feet " 4" "		
8.6	feet " 2" "		
$\frac{1}{2}$	pile.		

104.5 feet 24-inch on grillage, average cut 9 feet through sand and water; 866.7 feet of 24-inch on 2-inch cradle, average cut 14.5 feet through sand and water; 4 feet of 18-inch vitrified pipe, average cut 14.5 feet through sand; 373.4 feet 15-inch vitrified pipe, average cut 14 feet through sand; 302.3 feet 12-inch vitrified pipe, average cut 11.2 feet through sand; 218 feet of 10-inch pipe culvert; 2 catch basins on piles, 8 other catch basins, 12 manholes. This work was discontinued in December on account of frost. It was resumed the following April, the 12-inch vitrified pipe put in and the work completed.

The account was:

24-INCH ON PILE AND TIMBER.

52	days mason	cost	\$286.00
239.5	" labor	"	398.40
21	M brick	"	210.00
69	piles, 15 to 30 feet in length	"	250.00

24-INCH ON 2-INCH CRADLE.

61	days mason	cost	\$335.00
460	" labor	"	764.00
45	" team	"	135.00
95	M brick	"	95.00

18-INCH, 15-INCH, 12-INCH AND CATCH BASINS.

20	days mason	cost	\$110.00
224	" labor	"	372.00
1.5	" team	"	6.50
28	M brick	"	28.00

CEMENT ON ALL THE WORK.

358	bbls. Rosendale	cost	\$358.00
14	bbls. Portland	"	35.50
6,067	feet B.M. timber	"	146.00

The second piece had 149 feet of 24-inch with haunch walls, on pile and timber foundation, average cut 2 feet through mud and water; 30 feet of 24-inch on grillage, average cut 8 feet, through sand and water; 120 feet of 24-inch on cradle average cut 12 feet through sand; 918.7 of 15-inch vitrified pipe average cut 12 feet through sand; 503.8 feet of 12-inch vitrified pipe, average cut 12 feet through sand; 503.8 feet of 12-inch vitrified pipe, average cut 11.8 feet through sand; 188 feet of 10-inch pipe culvert; 2 catch basins on piling, 7 other catch basins, 12 manholes.

The account was:

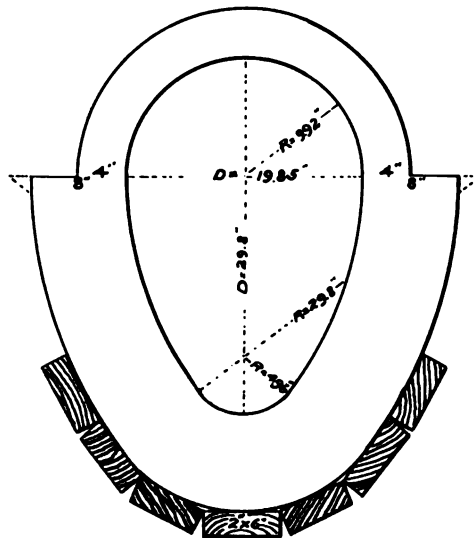
24-INCH ON PILE AND TIMBER.

60	days mason	cost	\$330.00
234	" labor	"	388.44
77	piles, 15 to 30 feet long	"	300.00
31	M brick	"	31.00
54	bbls. cement	"	54.00
840	feet B.M. timber	"	202.00

15-INCH, 12-INCH AND CATCH BASINS.

20	days mason	cost	\$110.00
20	" foreman	"	110.00
359	" labor	"	696.00
40	M brick	"	40.00
97	bbls. cement	"	97.00

The three following give some idea of the labor cost of doing work in mid-winter weather, with from 6 to 18 inches of frost. No note was made of the amount of materials used. The work consisted of 375 feet of 24-inch egg-shaped sewer, average cut 10 feet through sand and loam; 30.7 feet of 18-inch and 219.5



24-inch egg-shaped.
84 brick per lineal foot.
 $\frac{1}{8}$ bbl. of cement per lineal foot.

	18 INCH			15 INCH			12 INCH			10 INCH	CATCH BASINS MANHOLES		ROCK CUBIC YARDS
	Lineal Feet	Average Cut	Character of Excavation	Lineal Feet	Average Cut	Character of Excavation	Lineal Feet	Average Cut	Character of Excavation	Length			
(1).....				341.7	12.6	sand loam gravel	406.8	11.5	sand loam gravel	76	3	5	
(2).....				419.3	13	sand loam gravel	40	12.5	sand loam gravel	58	2	4	
(3).....				283.6	13	sand sand	373.7	13	sand sand	68	2	4	
(4).....				441.8	13	loam gravel	684.6	13	loam gravel	60	4	7	
(5).....				207.8	11.4	sand gravel	509.4	12.4	sand gravel	80	3	5	
(6).....				247.7	10.5	sand loam	231.8	10	sand loam	87		3	
(7).....				616.5	11.5	sand gravel	166	11	sand gravel	134	5	5	
(8).....				27.7	12	sand loam	519.6	11.5	sand loam	40	1	3	
(9).....				341	11	sand loam	1493.0	11	sand loam	95	3	11	
(1).....	407.7	9.5	sand water	384	10	loam rock water	437.9	11.5	loam rock water	135	7	9	855.4
(2).....	641.5	13	rock water	561.8	12.5	loam rock water	750.6	12	loam rock water	226	12	13	2087.0
(3).....				1091	11.5	loam rock	57.5	11	loam rock	133	6	8	1210.8
(4).....				326.4	12	sand loam	481.1	12	loam sand rock filling	138	3	6	113.3
(5).....							385.4	11	clay rock	64	1	3	211.0
(6).....	30	12.5	sand rock water	581	12.5	sand rock	47.6	12.1	sand	48	3	5	1.33
(1).....							300	10	sand	...	...	1	
(2).....							231	9.2	sand gravel	34	...	1	
(3).....							329.3	9	sand gravel	...	...	2	
(4).....							604	13	sand loam	48	2	4	
(5).....							424	12.5	sand	17	...	3	
(6).....							400.2	11.6	sand	63	1	2	
(7).....							231.5	13	sand water	34	...	1	

FOREMAN		MASON		LABOR		TEAMS		BRICK		CEMENT		
Days	Cost	Days	Cost	Days	Cost	Days	Cost	Thousand	Cost	Barrels	Cost	
.....		24	132.00	444.5	674.73	11	60.50	25	250.00	64	64.00	Contractor as foreman
14	28.00	9	49.50	259	430.00	7	35.00	12	120.00	35	35.00	
15	30.00	11	60.50	265	440.00			13	130.00	38	38.00	Contractors as foremen
24	48.00	20	110.00	422	700.50	14	70.00	22	220.00	50	50.00	
20	40.00	14	77.00	307	509.80	8	40.00	16.5	165.00	39	39.00	
13	26.00	3	16.50	144.5	240.00	3	13.00	5.4	54.00	12	12.00	
.....		15	82.50	300	484.00	14.5	43.30	23	230.00	58	58.00	
.....		14	77.00	217	236.00	2	10.00	8	80.00	24	24.00	
40	120.00	36	198.00	137	181.00	7	35.00	25	250.00	48	48.00	
73	146.00	25.5	122.40	120	1736.00	18.5	88.50	28.8	260.00	94	94.00	Pump hose...\$35.00 Dynamite, 2407 lbs. \$361.00 Battery.....\$25.00
178	979.00	36	193.00	1460	2423.60	28	140.00	35	350.00	85	85.00	Group II
109	218.00	28	154.00	2015	3345.00	25	125.00	22	220.00	82	85.00	
41	82.00	18	99.50	409	680.90	2	10.00	20	200.00	59	59.00	
.....		5	27.50	311.5	517.00	13	39.00	8.2	82.00	32	32.00		Dynamite, 208 lbs. $31.00
21	52.50	14	77.00	267	324.50	10.5	31.50	16.4	164.00	37	37.00	
9	18.00	1	5.50	86	142.70	1	5.00	1.8	18.00	10	10.00	Group III
10	20.00	1	5.50	75.5	125.30	2	6.00	1.8	18.00	10	10.00	
7	14.00	2	11.00	75.5	125.30	2.5	7.50	3.6	36.00	17	17.00	
18	36.00	14	77.00	250.2	372.30	2	10.00	12.8	128.00	31	31.00	
13	26.00	5	27.50	193	320.40	7	35.00	5	50.00	15	15.00	
13	26.00	6	33.00	138	229.00	.....	.....	7.5	75.00	16	16.00	
6	12.00	1	5.50	51.5	85.50			1.8	18.00	8	8.00	

feet of 12-inch vitrified pipe, average cut 9 feet, and 243.8 feet 18-inch vitrified pipe, average cut 10 feet through sand and loam; 34.5 feet 15-inch vitrified pipe, average cut 11 feet; 125.2 feet 12-inch vitrified pipe, average cut 10 feet through sand.

The labor on this was:

68	days mason	cost \$	374.00
73	" foreman	"	164.00
1,108	" labor	"	1,662.00

The second had 612 feet of 18-inch vitrified pipe, average cut 12 feet through filling, loam and sand; 43 feet of 15-inch vitrified pipe, average cut 15 feet through the same; 31 feet of 10-inch vitrified pipe, average cut 4 feet through sand and loam.

For which the labor was:

15.5	days mason	cost \$	85.25
26	" labor, foreman	"	65.00
344	" labor	"	516.00

And the third had 286 feet 24-inch circular brick sewer, average cut 7.5 feet through filling, mud and water.

The labor account was:

41.5	days mason	cost \$	228.25
42	" foreman	"	105.00
409.5	" labor	"	614.25
4	" team	"	20.00

I might add that the labor was undoubtedly high, due perhaps to the work being partly on a percentage basis.

On the preceding pages are three groups of similar size sewers arranged in tabular form for comparison. Group I shows nine sewers varying in size from 15 inches to 10 inches. Group II shows six examples in rock excavation from 18 inches to 10 inches in size. Group III, seven examples 12 inches to 10 inches in size.

THE STATE STREET OVERFLOW SEWER, NEW HAVEN, CONN.

By Henry J. Kellogg, Mem. Conn. Soc. C. E.

The work was begun in October, 1906, and completed in September, 1908, just two years elapsing in constructing the State Street Overflow; and of that time there were only two months when all work was suspended. Pile driving and placing rip-rap filled in during most of the winter seasons. With the traces of construction gone, there is nothing in sight to show that a rather difficult work has been accomplished, except a few feet of the end that projects into the water. Sewerage work has that disheartening feature, that, however excellent it may be, it is out of the sight and out of the mind of the public, except, perhaps, during a discussion over a bond issue or in case of its failure to carry off quietly and quickly an excessive rainfall. It is only then that most of the citizens think of the network of drains underlying the streets—as a revulsion of a man's intestinal system tells him that his alimentary canal won't take, without protest, everything he may put into it.

The city authorities did not need to be told that relief was needed; but action was withheld by reasons financial and by reason of the slow movement of municipal councils. Every rainfall of high rate caused flooding of the streets in the central portion of the city, and cellars were sometimes converted into water tanks. With the new sewer in commission for only the past four months we cannot yet publish pictures of before and after using, as we have had in that time no rainfall making a bogie score or near it. But of the rains that have occurred, some of which might possibly have made trouble under former conditions, none has caused any complaints. The connections designed to get the full benefit of the new outlet are not fully completed. When these are made it is expected that all precipitations, except of the cloud-burst type, will be handled in the section this overflow is intended to relieve, without causing serious trouble.

This section contains the heart of the city, where many of the blocks are nearly roofed over and where a large percentage

of the streets are paved with hard, smooth-surfaced, impervious material. The line of the sewer (in our judgment the only practical one) is along low ground; starting from Water Street, near State Street, thence running parallel with State Street through a lot owned by the railroad company, included in the tract known as the "Farm," and crossing Old Union Avenue to the land where the station is located, and which is lined with tracks. From there onward to tide water we had to pass under



SHOWING FINISHED BOTTOM AND VERTICAL BARS FOR
THE WALLS.

twenty-six tracks. The strip taken is almost entirely of made land over a thick stratum of mud; so low in elevation, that, to get the sectional area needed, the width had to greatly exceed the height. This excess was so great that the sewer was designed with a middle wall, making it a twin or double-barreled sewer.

Each barrel, if a nearly rectangular hole may be referred to as a "barrel," is 4 feet in height and 6 feet in width. The bottom is dished 4 inches, being raised at the sides $1\frac{1}{2}$ inches; and lowered at the water line $2\frac{1}{2}$ inches; thus keeping the proportions above given for area, while the actual height

from water line to roof is 4 feet $2\frac{1}{2}$ inches. The width across the top, outside, is 15 feet. The thickness of the top is considered 12 inches, although at the sides it is 11 inches, and at the center, over the middle wall, 13 inches, to give a side slope each way. The central wall is 12 inches thick with vertical faces. The side walls were designed to be 12 inches thick also, with vertical faces leaving a 6 inch shelf at the bottom on the outside, the bottom being 1 foot wider than the



ARRANGEMENT OF BARS IN ROOF.

top. But in construction a plain form, set for a batter, was used for the entire outside faces. This made the side walls 12 inches thick under the roof and about 16 inches thick where they rest on the bottom. It may be well to state here, that, in figuring the stresses, the walls, roof and bottom became more or less involved, and although in description the walls are considered as 3 feet $10\frac{1}{2}$ inches high, yet the effective height is about 6 feet. The bottom, which is 16 feet wide, has a thickness of 10 inches along the water lines of the two channels and 14 inches under the three walls.

A description of the arrangement of the reinforcement, without enlarged pictures, may be difficult to follow. Each wall has two rows of vertical $\frac{1}{2}$ inch bars, extending nearly through the top and bottom and set near the faces, 12 inches on centers and staggered. Half-inch rods, laid longitudinally in the bottom along the lines of the walls, were wired to the verticals at the lower ends; and the upper ends of the verticals were held in place temporarily by laying 8-inch boards along the trench



SHOWING RIP-RAP. MEADOW STREET OUTLET IN DISTANCE.

braces on the lines of the walls, with staples on each side spaced to catch the rods. When the walls were carried up part way, these boards were removed. In the bottom were laid $\frac{1}{2}$ -inch transverse bars, spaced 12 inches on centers, and bent to fit the dishings. Longitudinal $\frac{1}{2}$ -inch bars, 3 in each channel, secured these transverse bars from displacement in concreting, and the transverse bars were also wired to the longitudinals under the walls. In the top, $\frac{3}{4}$ -inch bars were placed every 4 inches, every other bar being a straight bar. The other bars were bent according to three patterns, to take shearing stress and possible contra-

flexure. These bent bars alternated and all extended across the entire width of the top, the bent bars rising at the middle wall as at the sides. About 4 inches of the ends of the bent bars were turned downward. Over the channels longitudinal $\frac{1}{2}$ -inch bars were placed in the top about the same as in the bottom. The transverse bars were also wired to the verticals. The bars were of open hearth mild steel, twisted.

For the first time in my experience bids were made on the



PILING.

unit system. That gave us freedom to increase or diminish quantities to suit the needs as we found them. The description just read fits the normal conditions and, except for the small deviations already noted, is according to the original design. What was done in construction is another matter and will follow.

The plans of the piling show the bents to be 3 feet on centers, 4 piles in a bent, 1 pile standing under each of the side walls and 2 piles, 2 feet on centers, under the middle wall. On each pair of central piles were laid two bars of $1\frac{1}{4}$ -inch size, 4 feet long, bridging the space between the piles to make them act as

one. This layout of piling was followed for most of the way. When we came to the main platform of the passenger station, we decided it would be impractical, if not impossible, considering the traffic, even without the further consideration of cost, to cut an open path through the roof wide enough for our pile driving. So we drove 3 rows on both sides of the platform, as closely as we could stick them. Each platoon of piles numbers about 30 piles and may be classed as an abutment. The concrete of the top was increased to about 18 inches in the thickness, of the bottom to about 22 inches at the water lines, and of the side walls to about 18 inches under the roof, the batter being a little less than the ordinary. In the top we placed 1-inch longitudinal bars, 6 to each channel and 2 to each wall. In the bottom we laid 1-inch and $\frac{3}{4}$ -inch longitudinal bars, and the transverse bars were made $\frac{3}{4}$ -inch, 6 inches on centers. In each of the three walls (and here regard them as involving the top and bottom), where the verticals were given 8 inches on centers, are pairs of 1-inch bars top and bottom (the top pair before mentioned) with another pair draped to form a catenary curve. All the increases of concrete extended both ways several feet back from the pile abutments and the longitudinal bars were carried back about 10 feet (and in the walls bent downward) for anchorage. The long bars lapped in the center about 10 feet. The span crossed is about 33 feet in the clear. The reason for not putting in more steel was that there was no room for it. This made a sort of double tubular girder. If the station platform were to remain as now located there would have been no need of such an increase of strength; but when the railroad changes are made that place will be occupied by tracks.

From the station outward, across fourteen tracks, we had to use the Railroad Company's apparatus for driving piles; their driver being mounted on a car. It worked well—when it didn't break down. We could only get two tracks at a time (we could not work with less room) and that liberty was only allowed of a Sunday, excepting two days toward the end when the freight traffic happened to be light.

The same scheme of bunching piles and bridging gaps was carried out in crossing under the aforesaid fourteen tracks beyond the platform; the spans varying slightly, but averaging 11 feet in the clear. The longitudinal bars were made continuous

by lapping and the concrete of the top and bottom, about 16 inches thick. I will mention here that the pile heads enter the concrete 4 inches in the regular work and in the line of the continuous girders, just described, they enter about 10 inches.

The full complement for a Sunday's work comprised the railroad pile driving gang, whose duty was limited to driving only; a locomotive and a flat car, with which went an engineer, fireman and brakeman, with a conductor for the whole train (a tool car



UNDERNEATH TRACKS. BOTTOM FINISHED.

goes with the driver); two flagmen to guard the workers and signal approaching trains from either direction; the contractor's two axemen to cut off the broken piles and the butts that could not be driven below the ties; the gang supplied by the firm to whom the regular driving had been sublet, whose part was to furnish the sticks, point and butt them and bring them from the "Farm" lot, one by one, to the driver; the track gang, who stood by to take up and relay rails and ties; and (I think this is the last), the bridge gang, who took up and put down the planking that extends 4 tracks beyond the platform. One Sun-

day the machine broke as the leaders were being raised. Another Sunday a gear fell from aloft in two pieces, with only three piles driven and not a duplicate gear this side of some town in Michigan. No work the next Sunday in consequence. But on the other occasions the machine worked well and the men exerted themselves to the utmost. We seldom got started before 8 A. M., because trains had to be shifted or broken, and we had to quit at 4.30 P. M. My recollection is that 38 piles was our best day's work. After getting onto the freight tracks we brought the



MIXING CONCRETE ON TRACKS OVER THE SEWER.

piles on a flat car. One Sunday we found the car of piles had not arrived but was at Northford, ten miles away, where it had been loaded but held for lack of inspection. I found the assistant yardmaster and with the help of the train dispatcher we got that formality waived and sent our engine for them. Pardon me for elaborating these details, but those were days of anxiety, the cost piling up rapidly and the work progressing slowly.

All tracks had to be supported while we worked underneath. The span across the trench, owing to the angle (about 51 degrees) at which we crossed, was 22 feet in the clear. A continuous row of piles, except at the platform, was driven on both

sides of the trench across the tracking. These piles were cut off and capped by the Railroad Company, who then bridged over the trench by laying four yellow pine timbers, 8 by 18 inches, 31 feet long, under each rail, with others between the tracks. The entire distance across tracks and platform was covered over with planking. The trench was sheathed by nailing boards to the railroad piles (as we designated them), or by driving short boards behind them. No parts of the forms or braces holding



MIXING CONCRETE ON TRACKS. A HOLD-UP.

the forms were allowed to touch the sides of trench in the track work. The deflection observed of the heavy timbers with a locomotive at rest was $\frac{1}{18}$ of an inch. With the same locomotive crossing at a speed of about 4 miles per hour, $\frac{5}{8}$ of an inch.

The concrete was of the proportions 1-2-4. The stone was crushed trap rock of the run of the crusher from $\frac{1}{2}$ to 1 inch size. The specifications relating to the qualities of the ingredients, method of mixing, handling and depositing, read substantially as like articles do in modern contracts. Most of the concrete was mixed in a Ransome mixer; but in the midst of the

tracks we were obliged to use shovels, the materials being brought in cars which lay on an adjacent track. It was awkward work. Interruptions were frequent from passing freight trains that seemed to be miles long, and from switchings. Two flagmen were constantly on guard and in spite of constant warning a workman would sometimes have to be pulled from in front of an approaching locomotive, or, what was more dangerous, the rear end of a train backing. When we were working on the tracks the freight traffic was heavy; but we had hardly finished there and were enjoying the freedom of the open yard when the late business depression began to show its effect, and, except for footing, we could have played baseball anywhere from Track 4 to the water.

Of the difficulties in giving grade, fall one inch in 1,500, there is nothing of importance to say. We have all been there. When the H. I. in the subway was plus, and the grade point minus (our water line started at 2.3 below average high water, and we worked down hill), standing in water, trains rolling and rumbling overhead, a candle light or a ray of daylight through a chink overhead to see by, I have more than once figured a foresight rod that was less than nothing or one long enough to stick up through the roof.

It is obvious that a line cannot be run through a busy passenger and freight yard on ground level. We established a point on the station platform roof and our backsight line split the back of the letter "G" in "LAGER" on a saloon sign. You could not forget it.

The finished work shows no errors in line or grade, which is to the credit of our inspectors. We have discovered no cracks, though some may exist. One leak was found in the westerly side wall, a small boy stream, that may still be harmlessly working. It was a pumping job, using a 4-inch pulsometer, until we neared the tide line, when the trench was cut through and the work was varied with the tides without losing time. No concrete was deposited in running water and new bottoms were protected from currents by low bulkheads.

The overflow was connected with the sewerage system by separating the two channels at Water Street. The easterly channel (increased in width to 8 feet) taps the State Street 54-inch sewer as it curves into Water Street, and the westerly

one taps the Water Street sewer beyond the curve. The easterly branch opens a large gap in the State Street sewer and has a temporary dam 13 inches high along the opening, which keeps the ordinary flow in its original bed. A curtain wall across the old sewer, on the downstream side of that opening, cuts off a greater flow and the excess must take the new course to tide water. That relieves the Meadow Street sewer. The westerly branch has a higher temporary dam and is now only effective in a setback from the Meadow Street sewer, one block to the



INTERIOR OF ONE OF THE TWIN SEWERS.

westward. If we had had sufficient funds to carry the overflow to the harbor line, where it is to go later, these dams would not be needed. The details of the projected further changes to be made at Meadow and Water Streets, to utilize the westerly branch, would require too much time for description and are not fairly included under the title of this paper.

The live load used in calculations was 45 tons on a pair of driving wheels adding 75% for impact. The impact was figured high on account of the very shallow fill over the top of the sewer, $2\frac{1}{2}$ feet to the bottoms of the ties. The calculations

for stresses were made in accordance with Burr's formulas given below. The ratio of elastic limit was taken as 12. All calculations were by Mr. Cassius W. Kelly, City Engineer, and Mr. J. Frederick Jackson, the latter being associated with me in the construction.

Formulas used:

$$d_1 = -\frac{E_2}{E_1} \frac{A_2}{b} \pm \sqrt{\left(\frac{E_2}{E_1} \frac{A_2}{b}\right)^2 + 2 \frac{E_2}{E_1} \frac{A_2}{b} (a + rh_2)}$$

$$M = K \left[\frac{bd_1^3}{3} + \frac{E_2}{E_1} \frac{A_2}{d_1} (h_2 - d_2)^2 \right]$$

$$w = \frac{8M}{l^3}.$$

When E_2 = coefficient of elasticity in steel.

E_1 = coefficient of elasticity in concrete.

A_1 & A_2 = areas of concrete and steel respectively.

b = breadth.

$r = 1$.

d_1 = distance of extreme compression fiber in concrete from neutral axis.

a = distance center compression in steel from extreme compression surface of concrete.

hA_2 = area section of steel in tension.

K = greatest intensity of bending compression in concrete.

d_2 = distance of center of compression in steel from neutral axis.

h_2 = total depth of steel from top of concrete.

$E_2 = 30,000,000$ $E_1 = 12$.

$E_1 = 2,500,000$ $E_1 = 12$.

$K = 500$.

Tensile strength of concrete neglected.

Tension in steel not to exceed 16,000 lbs.

We had borings along the line of the sewer made with a 1-inch jointed auger, turned by hand and carrying a load of 300 pounds—a crude method, but one that had answered our purposes. With the heavy live load assumed and with only 2½ feet of earth cushion below the railroad ties, we wanted to find out by practical test what a pile would support, so we drove a test pile in the freight yard. The pile selected was a straight, smooth, tight-barked chestnut, 12-inch butt and 7-inch tip, pointed. Hammer weight 2,000 pounds. Fifty-five 6-foot blows (the ring put on at the thirty-fifth blow) sent the pile down 17 feet. Twenty-five 10-foot blows made it 26 feet. Twenty of 12 feet increased the penetration to 29.5 feet, and twenty more

of the same to 33.5 feet. Fourteen more, of about the same drop, made it 36 feet, three 12-foot blows added 10 inches, another of the same 4 inches, a 15-foot one 4 inches and a final 20-foot blow 3 inches, making the total 37 feet 9 inches. The driving was one of the easiest we had made or did make. This result was only satisfactory as enabling us to test a pile that did not drive to a refusal. It was not what we expected from previous drivings. The pile was not split, the bark stayed on



TEST PILE, FINAL LOADING, 35 TONS.

and the head was left hard and smooth. We found a $1\frac{1}{2}$ -inch iron plate, about 14 by 40 inches, with a 2-inch hole, conveniently located; and we laid the plate on the pile, centering the hole, and drove a spike through the hole into the pile, leaving the head of the spike just above the plate to rest the rod on. With the plate as a base we built up a criss-cross pile of rails, carefully balancing them, and with 35 tons of rails, our final load, the

whole mass could be easily swayed. We were fortunate in having material at hand. The contractor had rails and ties for the taking and with them built his dummy lines. As Kipling wrote of literary borrowings: "And what we thought we might require we went and took."

First load, March 26, 1907,	18,900 lbs.	subsidence	.010
Increased, " 27 " to 30,200 "	"	"	.027
" " 28 " " 37,400 "	"	"	.033
Same " 30 " " "	"	"	.040
Increased, April 3 " to 49,800 "	"	"	.075
Same " 6 " " "	"	"	.082
Increased " 6 " to 60,200 "	"	"	.130
" " 17 " " 70,800 "	"	"	.300

Same load slowly increased the subsidence during the spring and summer until, in August, it reached 0.570, when it appeared to stop.

With the above record for slipperiest pile and one of the easiest drivings (there were few that could compare), we feel sure that 10 tons per pile is safe loading for us to assume for that work. At least 10 piles will be engaged with a load applied at any point. Our driving was done first and the excavating followed. We found that we had in places driven through stone walls, dock fronts and grillage. One pile bored a hole lengthwise through an old pile.

The total cost of the overflow, to the city of New Haven, was \$73,512.98. The length is 1,500 feet.

To give the entire cost of the work, we would have to include the work done by the corporations holding franchises whose lines were affected. The Street Railway Company had to bridge over the trench and shift tracks; the Western Union Telegraph Company was obliged to take down and reërect over 100 wires; the Telephone Company was slightly affected; the New Haven Water Company were put to some expense and the New Haven Gas Company had to drive piles and suspend large mains.

It is a pleasure to be able to state, that during the protracted period when we were of necessity continually breaking in upon the duties of the railroad people and causing them extra work and trouble, we were invariably met with courtesy and given valuable assistance.

DISCUSSION—REINFORCED CONCRETE SEWER AT NEW HAVEN.

MR. LEWIS: Mr. President, I would like to ask Mr. Kellogg a question—if there is a tide gate to this outlet, and if so, if in case of very high tide and at some storm it would not have a bad effect on the sewerage system?

MR. KELLOGG: Mr. President, a tide gate to keep back a high tide would be impracticable because we would have to lift the gate to let out the flood that was working in the sewer under head. The easterly branch was 8 x 4, tapping a 54-inch sewer. Now that I speak of it, you can see the great difference in areas, an 8-foot by 4-foot tapping a 54-inch sewer. To give water free access to act in an overflow, a large surplus of area is given to allow the water to bore a hole through itself and thereby relieve friction, and the slightest head will produce a current.

THE PRESIDENT: I would like to ask Mr. Kellogg if they found any difficulty in joining the work of one day with the work of the next day, or when stoppage was made, in placing concrete?

MR. KELLOGG: Some of the work was left for I think nearly a year before we went on with the new. We picked and roughened the surfaces, washed them, and put on sort of a neat cement lining, or plaster, you might say, or paste, so as to make them tight as well as we could. I don't know that I mentioned it, but so far as we have examined the sewer we haven't found any cracks. I dare say there are cracks there, probably some will come in, but so far as we could see by the light of a candle there were none.

AN EFFICIENT INDEX SYSTEM FOR CITY ENGINEERS' OFFICES.

By Wm. Gavin Taylor.

The indexing and filing of plans, field notes, office calculations and other records in a city engineer's office is an important feature of the routine work. An efficient indexing system is a valuable tool and time-saving device—one which can easily produce actual dividends in time and money saved far in excess of the actual cost. Happily the older method, of burdening the mind of one of the assistants with the records of the office and the relative or probable location of a plan, book or other item, is disappearing and with it the thought that the spending of money on indexing and filing equipment is to be avoided.

Success in a filing system is marked by the ease and rapidity with which desired data can be found, and this depends primarily upon two elements: First, the fundamental structure of the system used; second, the faithfulness with which the system is operated. The best possible system under careless use produces poor results, and a relatively poor system handled with faithfulness may give general satisfaction.

In 1901, while City Engineer of Medford, Mass., the writer made a study of indexing problems with special reference to the needs of the engineering office of that city. All available published data were read, and numerous systems in operation in other cities were carefully investigated.

The indexing methods examined could in general be classed under two heads: First, those in which cards were located alphabetically under the guidance of some key-word selected by the indexer; second, those in which the cards were arranged under the guidance of some color scheme.

None of the systems found in use in other offices seemed entirely satisfactory for the needs of the local office. And here it is well to emphasize the fact that indexing methods are not always interchangeable; that a certain system may admirably fit conditions in one city and be unsuitable for those of another; and that there is no one *best* system applicable to all cases and conditions.

A study of the indexing system devised by Melville Dewey, sometime State Librarian of New York, and adopted in many public libraries for the classification of books, pamphlets, etc., according to subject matter, brought forth admiration. The principle upon which the system is based seems the most rational, direct and positive of any yet devised.

41						
REMARKS.						
Harvard Ave to Lawn Terrace						
Profile of 30 inch Water Main						
ACCESSION No	DATE	ENGINEER	HB	PAGE	Cust Com	No
3750	July 2, 1899	A.R.B.	82	190	6 5	13
FILE UNDER						
Florence Street						

Fundamentally Dewey's decimal indexing system is directly opposed to those embodying a color scheme or the use of key-words. It stands in a similar relation to these latter systems that an ordinary dictionary does to March's Thesaurus. In the use of a dictionary you can, if you have a word (the "key"), readily find its proper pronunciation, derivation and meaning, but the

reverse process cannot be worked; that is, you cannot start with the meaning—the idea—and find the word. March's Thesaurus, however, is based on *ideas* and attempts to cover the field left open by the dictionary as above pointed out. A concrete illustration has value in emphasizing the advantages possessed by an index systematized by *ideas*. Suppose one has in mind the thought that in a certain part of India, Asiatic cholera is native and always present, and it is wished to describe such a condition by the use of a single word which is either unknown or forgotten. The word "epidemic" comes to mind, but it fails to carry the precise meaning of the word sought for. The desired word is a condition of health—sickness, and with this as a starting point the exact word "endemic," conveying the idea, is readily found. The final result would have been the same if the words "epidemic," "disease," or any other word approaching the idea had been looked up.

In the decimal system of indexing the subject matter is systematically grouped and numbered in a degree of detail sufficient for the purpose in hand. Certain parts of the index system may be much more elaborately subdivided than other parts, the character and amount of subdivision depending, in the main, upon the particular case. For best results the subdivision of ideas should be carried sufficiently to limit the collection of but a few cards under any one number. If under continued use more cards accumulate under any subdivision than is desirable, its idea should be split into two or more specific classes, additional numbers given to the new divisions, numbers added to the cards in the original subdivision under enlargement and the cards rearranged. In like manner the index may be expanded indefinitely, the enlargement of sections and the development of new ones being as natural as the forming of new cells in a growing plant.

The reference cards are numerically arranged in the index and all cards are gathered in groups, each group covering a particular phase, and having a definite and predetermined relationship with all others.

The decimal system has very great flexibility and an infinite extensibility, and is therefore exactly suited for either the very small or the very large index. It also avoids the ambiguity which frequently arises in the use of an alphabetical system, and which cannot be avoided except through elaborate cross-indexing.

With Dewey's invention as a basis a system was evolved to fit the particular needs of the Medford office, and this system, with modifications, has been adopted for the filing system in the office of the City Engineer at Waterbury, Conn. Care was taken to effect a logical arrangement in the "index guide" and to maintain simplicity and uniformity throughout. The index guide is a schedule of ideas, a standard by the use of which each index card is definitely numbered and definitely placed in the index. The personal equation of the indexer does not enter into the relative placing of the cards; all is prescribed by one standard, and the difficulties arising through the use of key-words are thus avoided.

In common use the index guide was but infrequently referred to by the office assistants, as they soon gained through memory the sequence of numbers. Yet the index guide was sufficiently elaborate to permit a person not previously acquainted with the system to readily find a desired card having reference to a survey, level note, calculation or observation, plan, photograph or contract.

A primary division in the index was made by assembling the cards under cover of a tab guide card bearing the name of a street, or some important controlling natural object, as a water course—Massachusetts Avenue and Mystic River as examples. A secondary division was then made by establishing 12 subdivisions, each of which was given a whole number, as 1, 2, 3, 4, etc. These secondary divisions depend upon the needs of the office and may be as follows:

- | | |
|---------------------|---------------------|
| 1. Highways. | 7. Electricity. |
| 2. Sewers. | 8. Public Property. |
| 3. Sewage Disposal. | 9. Cemeteries. |
| 4. Storm Drains. | 10. Water Courses. |
| 5. Water Supply. | 11. Bridges. |
| 6. Gas. | 12. Railroads. |

Other secondary divisions may, of course, be added at will. Each of these divisions is visibly marked upon cards by means of $\frac{1}{16}$ tabs and the numbers plainly printed on the tabs. Tab 1 is at the extreme left of the 3 x 5 inch card and tab 12 at the extreme right. Tertiary divisions are then made, basing the divisions upon the class or character of the subject, the divisions being numbered at the right of the decimal point as follows:

- | | |
|-----------------------------------|-----------------|
| .1 Surveys and Stakings. | .4 Plans. |
| .2 Levels and Grades. | .5 Photographs. |
| .3 Calculations and Observations. | .6 Contracts. |

The tertiary divisions are subdivided to any desired extent by adding figures in the hundredths and thousandths place. In arranging the subdivisions of a system it should be borne in mind that uniformity throughout the system is the desideratum.

Specific cards frequently referred to may have their precise location marked by placing directly in front of them a colored tab card bearing the specific number, the colored tab card thus serving as a flag. A case that comes to mind is this: Cards referring to profiles were, as a class, in more frequent use than any other. The reference number for a profile was always .411 and so, directly in front of the profile reference cards, was placed a blue $\frac{1}{8}$ tab card numbered .411. Following down under any particular street the highway profile cards are flagged under 1.411, the sewer profile under 2.411, the storm sewer profile under 4.411, the gas main profile under 6.411 and so on. In the Medford index the profile cards are the only ones thus far that are flagged, but as the index grows more may be added if desirable. At the present time this index consists of about 35,000 cards, placed in 40 drawers.

An elaboration of one of the secondary divisions will give an idea of the amount and character of subsequent subdivisions.

INDEX GUIDE.

ELABORATION OF HIGHWAYS (Subdivision 1) IN A MANNER SIMILAR TO CARD INDEX SYSTEM AT MEDFORD, MASS.

I. HIGHWAYS.

- | | |
|------|------------------------------|
| 1.1 | <i>Surveys and Stakings.</i> |
| .11 | Street lines. |
| .12 | Land divisions. |
| .13 | Buildings. |
| .14 | Development—Construction. |
| .141 | Grading. |
| .142 | Pavements. |
| .143 | Edgestones. |
| .144 | Sidewalks. |
| .145 | Cross-walks. |
| .146 | Gutters. |
| .147 | Trees and planting spaces. |
| .15 | Survey and Traverse lines. |

- .16 Triangulation.
- .17
- .18 City lines.
- .19 Miscellaneous.
- 1.2 *Levels and Grades.*
 (Subdivisions similar to above.)
- 1.3 *Calculations and Observations.*
 (Subdivisions similar to above.)
- 1.4 *Plans and Profiles.*
 - .41 Street lines, acceptance plan.
 - .411 Official grade lines.
 - .42 Land divisions.
 - .421 Assessor's plans.
 - .43 Buildings.
 - .431 Restriction lines.
 - .432 Street numbering plans.
 (With similar continuation.)
- 1.5 *Photographs.*
- 1.6 *Contracts.*

The elaboration of the other secondary divisions, Sewers, Storm Drains, Railroads, etc., is made in a similar way, the detail figures being kept uniform throughout the whole system so far as practicable; e. g., the tertiary divisions should be absolutely constant and their further subdivisions as nearly so as possible. In the index cited .1 is always a survey note, .3 is always a calculation, .4 always a plan, and further, .411 is always a profile. By maintaining such a constant sequence in the figures the mastery of the system becomes easy and the efficiency enhanced.

To show the ease with which a reference card may be found, let it be assumed that the plan case location is desired of the profile of the 30-inch water main on Florence Street between Harvard Avenue and Lawn Terrace. Turning to the guide card marked Florence Street we have before us all the reference cards relating to Florence Street. The subject sought is one classed under Water Supply, so we look for tab 5 cards, remembering that profiles are flagged by a colored guide tab marked .411. We touch this colored tab, tipping it toward us, and find immediately back of it the cards referring to water main profiles on said street. If the street is not very long but one card is numbered .411, and that is the particular one sought for (see illustration).

As an example showing the operation of the system, let it be desired to assign a number and write a card having reference to the survey and level notes made in staking out the edgestone or

curbing in front of No. 1,642 Boston Avenue. By reference to the index guide the number 1.143 is at once assigned to the survey notes and 1.243 to the level notes. On long and important streets, such as the one cited, it may be that quite a number of reference cards will accumulate, each bearing the same number, as 1.143 in the example. These cards of like numbers are arranged according to relative position on the street, or numerically according to house numbers.

An accompanying illustration shows the arrangement of an individual card and the character and appearance of a series of cards with tabs and guide cards.

In operation this system is simple, easily understood and conveniently operated, and is successful and efficient. One assistant should be given the general supervision of the indexing work in an office, be final referee for all disputed questions, and be held responsible for successful operation of the system in use.

Since arranging the system herein described (1901) the literature of the subject has been greatly extended and the decimal system has made a marked advance. Among the more important articles published in the technical periodicals, the following list of citations is given as an aid to those who may desire to read further on this subject:

Boston Elevated Railway Co. Description of method of filing plans, notes and other records. Paper read by H. C. Hartwell before Boston Society of Civil Engineers. Abstracted in *Engineering Record*, 59.152 (1909).

New York Board of Water Supply. Detailed description of filing system adopted. A valuable and suggestive article by J. Leo Murphy. *Engineering News*, 60.137 (1908).

Salt Lake City, Utah. Describes an elaborate system of filing engineering notes and records used by the City Engineer. *Engineering Record*, 57.153 (1908).

Method of filing records in a city surveyor's office described by Fred Gabelman. *Engineering News*, July 20, 1905.

Engineering Index and Library Work. Description by G. W. Lee of system in use in the reference library of Stone & Webster. Also editorial. *Engineering News*, June 16, 1904.

Hartford, Conn. Description by Frederick L. Ford of filing system of field notes and drawings in use in the City Surveyor's office. *Engineering Record*, May 7, 1908.

Filing System in Engineering Department of the Chicago & East Illinois R. R. *Railroad Gazette*, May 8, 1908.

Engineering Industries. An extension of the Dewey decimal system of classification. Bulletin No. 9, University of Illinois, November 1906.

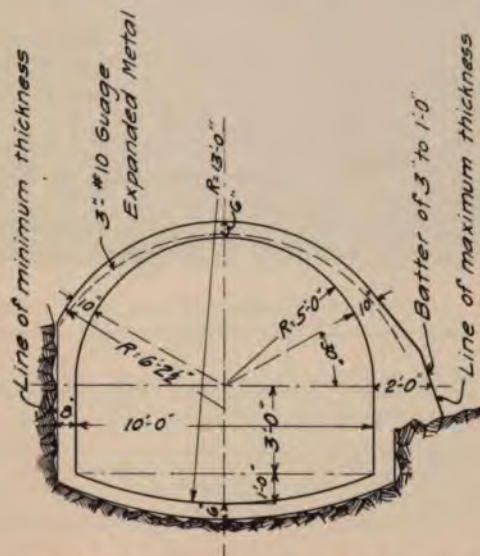
The same for application to architecture and building. Bulletin No. 13, University of Illinois, November, 1906.

TUNNEL AND CONCRETE SEWERS AT HARTFORD.

By Roscoe N. Clark, Mem. Conn. Soc. C. E.

There are at present, as part of the sewer system of the city of Hartford, three pieces of concrete sewer and one combination of concrete and brick. Naming these in chronological order they are: First, the Folly Brook conduit, so called; second, sewers in Ann and Asylum Streets, and across part of Bushnell Park, together forming the major portion of what is known as the Ann Street sewer system; third, the Gully Brook section of the Homestead Avenue intercepting sewer system; and fourth, the combined brick and concrete section, a little more than half a mile in length, known as Section "B" of the Homestead Avenue intercepting sewer system.

The Folly Brook conduit was built to enclose a portion of the length of a small water course in the southern part of the



TYPICAL SECTION OF FOLLY BROOK CONDUIT.

city, which in addition to the natural drainage facilities it provides, also serves as a storm water conduit for the relief of the six-foot Franklin Avenue sewer.

The excavation for this conduit was in rock cut for its entire length, and consisted of deepening and widening the natural bed



FOLLY BROOK CONCRETE CONDUIT.

Showing concrete bottom in place and rock shaped for concrete sides of conduit.

of the brook. The material is a brittle, shaly sandstone, and the line of cutting was in general parallel to the direction of the dip of the strata. The character of the rock was such as to make easy trimming, and the sides and bottom of the finished excavation were even more uniform than if the cutting had been through clay.

The dimensions of the finished work are a semicircular arch of 10 feet diameter, on vertical side walls 3 feet high; the invert being a concave arc with a radius of 13 feet, giving a middle ordinate of 1 foot. The natural stone abutments, of course, cut down the required thickness of concrete at the sides, an 8-inch



FOLLY BROOK CONCRETE CONDUIT.
Showing bottom and sides as constructed and centering for arch.

thickness of lining only being used, while the arch is 6 inches at the crown, and 10 inches on a line 30° up from the springing with a line of three-inch mesh expanded metal. This conduit terminates at its upper end in an enlarged bell-mouth with two inlets, one for the brook and the other to divert storm water from the six-foot sewer from the Franklin Avenue district. This section is 600 feet in length and cost, including the bell-mouth

and some 700 yards of extra excavation, about \$12,000, the contract price per foot being \$13.94. Below the springing line 1-3-5 concrete was used, while the arch was 1-2-4. The invert between the side walls was placed first, then the walls up to the springing line, and then the arch.

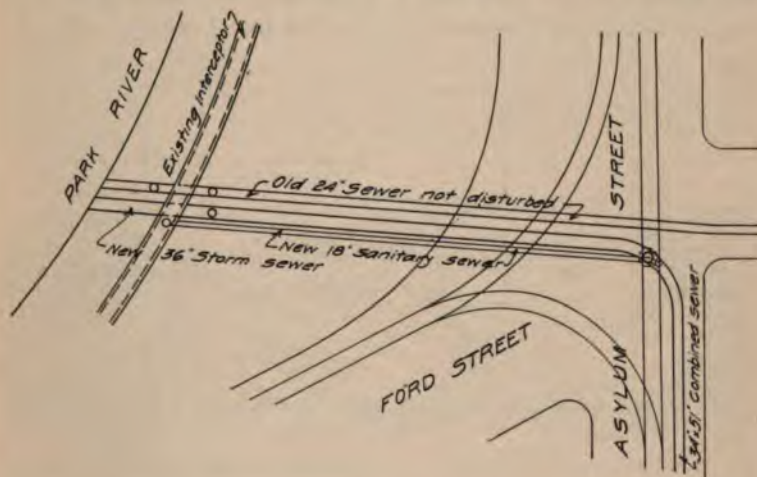


FOLLY BROOK CONCRETE CONDUIT.

Showing construction of bell-mouth at the junction of Folly Brook with the Franklin Avenue sewer overflow.

The Ann Street sewer system was designed to furnish sewerage facilities to the thickly settled business district bounded by Main Street on the north, Trumbull Street on the east, Asylum Street on the south, and High Street on the west. Property owners and tenants in this district, and especially in the lower part of Asylum Street, had for a long time been troubled with

flooded basements during heavy rain storms. The sewer replaced was one of the earliest trunk sewers in Hartford, having been built in the early '50's. It was originally an open drain, or small brook, extending in a general southwesterly direction diagonally across the district, and emptying into Park River near what is now Ford Street. As the district developed, this brook became more and more contaminated with sewage till it was found advisable to close it in. This was accomplished by simply building vertical walls of dry rubble, and laying flat cover stones across, making a box culvert of rectangular section some two

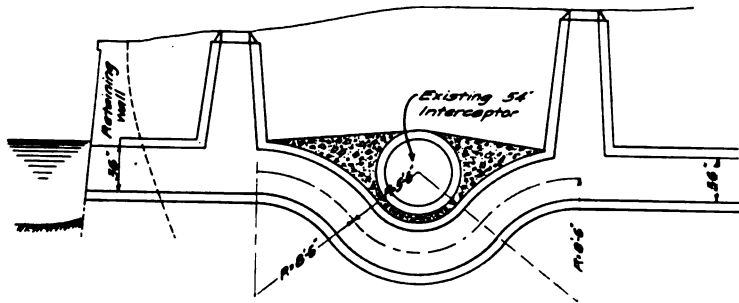


and one-half feet square. As may be easily imagined, this was an extremely difficult sewer to keep clean, and when, a few years since, evidences of caving in began to manifest themselves, it became evident that the need for a new and larger sewer was imperative.

Without going into the history of efforts made to get this sewer, suffice it to say that it was finally ordered, in part, and the contract awarded in July, 1907.

This contract called for 150 feet of 36" diameter storm-water sewer, 615 feet of combined storm and sanitary sewer of egg-shaped section, 34" x 51" diameter, 355 feet of 36" diameter combined sewer, and about 600 feet of vitrified tile sewer of various sizes, besides manholes and other appurtenances. The

36" storm sewer extends from the outfall at Park River to the corner of Asylum Street and High Street, passing under, by means of an inverted syphon, a 54" sewer running parallel to the river wall. Parallel to this storm sewer, and at a somewhat flatter grade, is an 18" tile sewer carrying to the intercepting sewer the dry weather flow from the entire district, and connecting at grade with the large egg-shaped sewer in Asylum Street. When the flow in this latter sewer has attained a depth of 18", it begins to overflow into the 36" storm sewer, and is by it carried to the Park River. Since the normal dry weather flow in the Asylum Street sewer is only about 6" deep, and passes entirely into the interceptor, the overflow into Park River is very



36" STORM WATER-SEWER, SHOWING SYPHON UNDER INTERCEPTOR.

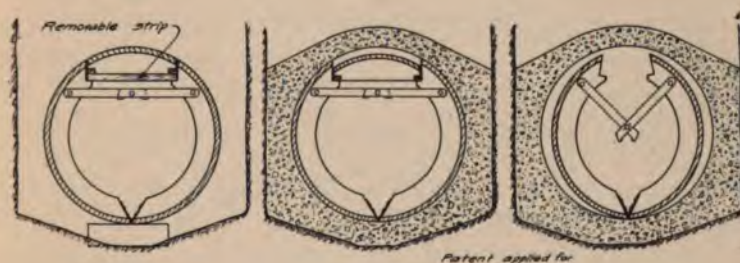
dilute in sewage, becoming less contaminated as the discharge increases.

With the exception of the tile sewers mentioned, all the conduits in this system were constructed of concrete.

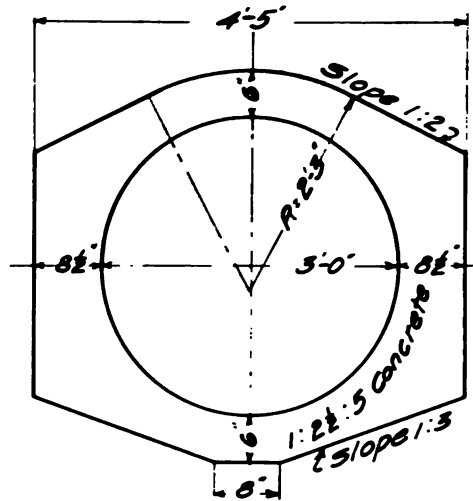
The 36" storm sewer and the parallel sewer of 18" tile, being spaced 3' 6" center to center, only a single trench was excavated. The cutting averaged about 14 feet in depth, and the material, which was miscellaneous filling at the top and wet clay on the bottom, was taken out by hand and piled along the sides of the trench. The cross section of these two sewers forms practically a complete monolith, the concrete of the 36" sewer being extended to surround the 18" tile.

As soon as the contract was awarded, arrangements were made by the contracting firm to procure collapsible steel forms for use on both circular and egg-shaped sections. In order not to delay

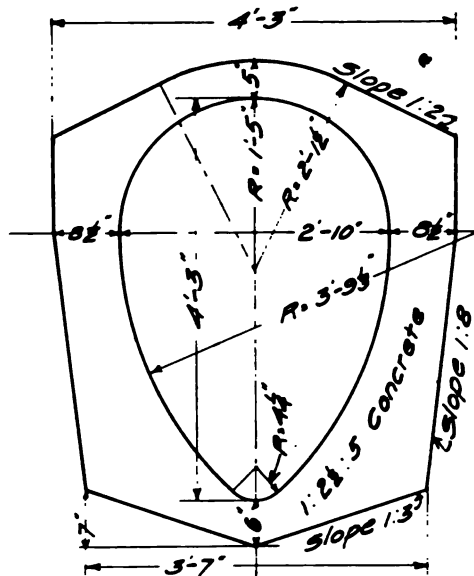
the work, however, wooden forms for the circular section (which was started first) were made by a local joiner, and these proved so satisfactory that similar ones were afterwards made for the egg-shaped section. These forms consist of two segments of about 150° each, hinged at the bottom and connected at the top by a folding brace, which when extended holds the segments in the proper position to form a continuous arc of 300° . A third segment (of 60°) is then slipped vertically into notches in the ribs of the two lower segments and is held in position to complete the circle by loose strips about two inches in thickness. In order to remove the forms after the concrete has set sufficiently, it is only necessary to remove these loose strips, when the upper segment drops vertically two inches, and may be drawn out endwise, after which the two lower segments may be drawn together at their upper ends and then removed bodily from the completed section of sewer.



The excavation for the egg-shaped sewer in Asylum Street was accomplished by means of the Moore trench machine. This apparatus consists of a carriage or traveler, shaped somewhat like an inverted U, the legs spanning the trench, and bearing at their lower ends small railway trucks which run on a track of about 8-feet gauge. At the top of the carriage are the necessary pulleys and brake levers and a platform for the operator. The carriage is moved back and forth along the trench by means of a steel cable, passing through a stationary pulley fastened to a stiff-leg at one end of the trench, and having its ends wound on the drums of a double-drum hoisting engine at the other end of the trench. At the carriage this cable passes through a set of pulleys so arranged as to leave a bight, carrying a third pulley with a hook from which is suspended the bucket, or the grappling



SECTION IN ANN STREET.



SECTION IN ASYLUM STREET.

hooks, or whatever means is used for handling the load. The sequence of operation is much the same as with the well-known Carson machine.

In constructing the egg-shaped section in Asylum Street and the 36" circular section in Ann Street, it was necessary to take care of the regular sewage flow in these two streets, as the old sewers had to be removed before the new ones could be built. A line of 8" vitrified tile was laid below and parallel to the grade of the flow line of the sewer. This tile was laid with open joints, and the trench around and over the same filled with crushed stone up to the proper height to receive the concrete for the sewer itself. Wherever laterals from the old sewer were encountered, Y-branches were placed, and to these the laterals were temporarily connected. A sump was built at the lower end of the Asylum Street section and a pulsometer installed there which overcame the slight difference in elevation between the tile drain and the new 18" sewer. A second pulsometer was installed at a manhole ahead of the work and discharged into a line of galvanized iron pipe of large bore, laid in the gutter and carrying back to empty into the completed section at its lower end.

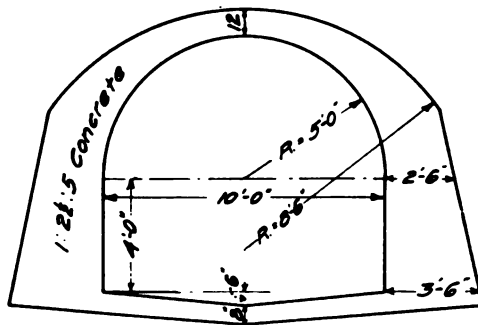
As soon as a stretch of sufficient length had been bottomed out, and the underdrain placed and covered, with crushed stone, the forms were placed and braced in position for the concrete. These forms were made in 12-foot sections, and from three to six sections were covered at a time, as circumstances permitted. A wooden bulkhead was placed at right angles to the sewer at the forward end of the section to be filled, and the concreting was then started and kept up without intermission till the section was complete. Slants of vitrified tile were placed against the forms at proper intervals for receiving the old laterals and such new ones as seemed necessary.

The concrete was mixed by hand, usually by two gangs of from six to ten men each, on large wooden platforms which were moved along as the work progressed, the concrete being usually shoveled directly from the boards to the forms without wheeling. Men with proper tools for tamping and placing the concrete were placed in the trench, and as a rather wet mixture was used, both sides were brought up simultaneously. Back filling was usually started about ten to twelve hours after concreting, but the forms were not removed till after forty-eight

hours. Soft soap was brushed over the forms to prevent the concrete from sticking. The back filling was done in part by dumping from buckets by the trench machine, and in part by carts hauling from a spoil bank. The material was well rammed by hand, and notwithstanding the fairly deep cut, the trench showed very little settlement at the surface.

The cost of excavation, back filling and carting was about \$1.67 per cubic yard of earth moved; and for the stock and labor of handling about \$6.18 a cubic yard of concrete in place.

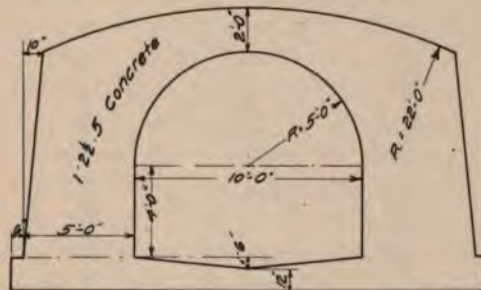
The Gully Brook section of the Homestead Avenue intercepting sewer system is a horseshoe-shaped section consisting of a



Section in Open Cut

semicircular arch 10 feet in diameter, on vertical side walls 4 feet high. The invert is V-shaped, the center being 6 inches lower than the sides. This conduit is an extension of one built many years ago to enclose that part of Gully Brook which lies within the more thickly settled portion of the city, and extends from Park River, opposite the Union Station, northerly across Asylum Street and under the station, and so on up through Spruce Street and the yards of the Central New England Railway to the northerly side of Edwards Street. The various sections of this old conduit were evidently built at different times, as some are of brick, while others are of brownstone. The floor is of plank laid crosswise and extending under the abutment walls. These walls are of heights varying from 1 to 3 feet, and except for the semi-circular arch of 10 feet diameter, there is a decided lack of uniformity in the cross section.

The new conduit, then, commences at the upper terminus of the old one and follows generally what was the bed of the open brook for a distance of 1,000 feet and joins a second culvert of similar size and shape which carries the brook under Walnut Street. For about three-fourths of its length the cutting was very shallow, in some places the springing line of the arch being above ground, but for a distance of 125 feet it passed under a roadbed of six tracks of the Central New England Railway. As all of the earth had to be removed, piles were driven on either side of the center line of the conduit and far enough apart to allow a clear span at least one foot greater than the interior width of the section. These were capped with 10" x 10" yellow



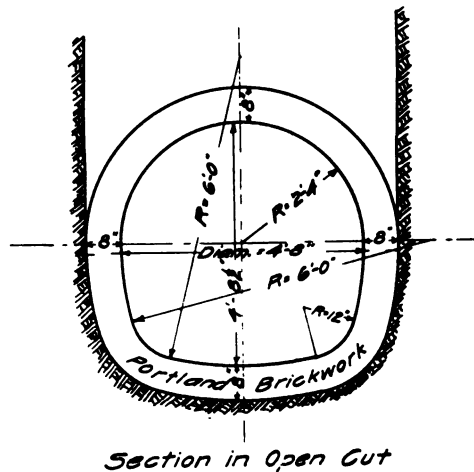
Section under Main Tracks

pine, and the bents thus formed were spanned by 8" x 16" yellow pine stringers carrying the tracks. As fast as the material was taken out from between the pile bents, sheeting plank were placed horizontally behind them, working from the top downwards. This section under the railway was built on a curve of 190 feet radius.

Three different cross sections for the conduit were used, the size and shape of the opening being the same in each case. The standard section was 8" thickness of invert, abutments 3' 6" at the base, with the inner faces vertical and the backs on a batter of 1 in 4; the arch, 12 inches at the crown and 24 inches at 2 feet above the springing line. The intermediate section, used under certain side tracks of the railway, had abutments 4 feet thick at the base, with a straight batter of 1 in 7½ carried 3' 6" above the springing, and a crown thickness of 18". The heavy section used under the main line tracks had abutments 5 feet

thick at the base, the backs carried upon a batter of 1 in 12 to the level of the top of the sewer inside, and an arc of 22 feet radius carried across to give a crown thickness of 24 inches. No reinforcement was used on any part of the work. The materials encountered were clay and hardpan, and except under the railway tracks, were handled by means of a stiff-leg derrick operated by a hoisting engine. The concrete was all machine mixed and wheeled in small cars running on a track laid over the completed work. The mixer was shifted during the progress of the work so that the haul was in no case over 200 feet.

When a sufficient length of trench had been bottomed out (usually 12 to 16 lineal feet), concrete to the required thickness



was deposited thereon. A template board cut to form the V of the invert was set for line and grade, and the surface of the concrete struck smooth with a wooden straightedge. After this had set sufficiently to bear walking on, the forms for the abutments were set in place and filled. These forms were of wood, with the surface to form the interior of the conduit covered with galvanized sheet iron. After the abutment concrete had set up for a day, the collapsible steel center for the arch was pulled ahead from the section previously completed, smeared with coal oil and covered with the arch concrete.

Some difficulty was anticipated in fitting the steel center around the arc on the curved portion, but the middle ordinate was only

about an inch for the 10-foot section, and no trouble was experienced.

The contract prices for the several sections were \$22, \$35 and \$55 per foot for the light, medium and heavy, respectively.

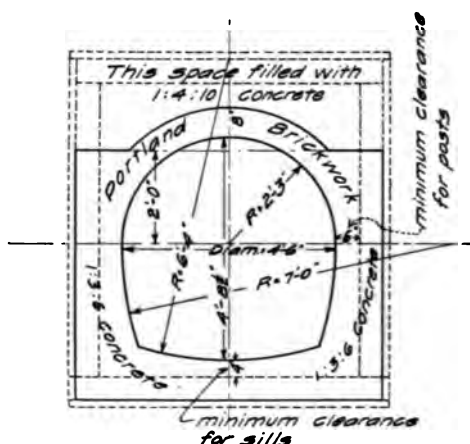
The tunnel section of the Homestead Avenue intercepting sewer system is a section in the middle of the trunk sewer some 2,800 feet long. The depth below the surface runs from 22 to about 40 feet. The sewer is an oval, approaching a horseshoe shape, 4 feet 6 inches wide and about 4 feet 8 inches high, with a semicircular arch. The contractor started his excavation by sinking shafts 700 feet apart on the line of the sewer. These shafts were about 8 feet in the clear, and after he dug down as far as he thought advisable, to keep the sides from falling in he started putting sheeting planks that were long enough to reach the bottom of the shaft up to 24 feet in depth; beyond this depth 24-foot sheeting was driven to the bottom and shorter ones inserted at the top. After the shaft had been completed, the headings were started, the material being taken out with a hoisting engine, and after the headings had been driven some six or eight feet, enough to get the portal well established, an elevator cage, which was to serve for the entire construction of the heading, was put in place, and operated by the same hoisting engine. The headings, as before stated, were started in some six or eight feet before the cage was put in place, and for the first few feet the timbers were spaced very close together, from a foot to eighteen inches. After this the timbers were placed about three feet on centers and were 6" x 8" and 8" x 8" stuff and sheathed with 2-inch plank on all four sides.

Instead of driving poling boards in setting each succeeding head frame, the material was taken out the entire distance between frames (it was of such a character that it could be removed without causing serious inconvenience), and the frame put in position, tamped firm, and then the plank for the roofing was put in diagonally and straightened around, with the exception of the center plank. A narrow cutting was then made in advance of the frame, on center, and the last plank pushed ahead from below and then drawn back in position to complete the roof.

The bottom was planked as well as the sides and the concrete for the invert placed on that. Masonry work was deferred until the headings met, and was then started in the center and worked

toward both ends, these headings each being about 350 feet long, the entire length between the shafts 700 feet.

The invert was placed first, then the side walls; these were of concrete. On the side walls an arch of brick was started, the masonry being, for about two-thirds of the height, carried from side to side of the excavation. As fast as the arch was completed, a back filling, sometimes of concrete and sometimes of dry sand, was packed into the opening above, the character of the back fill depending in a measure on the character of the material taken out.



Section in Tunnel

The work was carried along night and day in two shifts of ten hours each, the men below being usually five in number, the miner and helper, or "mucker," and three men who handled the car. Aboveground were two men to handle the car and one engineman. Over each shaft was erected a timber frame, with a platform six or seven feet above the surface of the ground. At this platform terminated the elevator guides, and a short section of railway extended from the position of the edge of the elevator, when level with the platform, outwards and then downwards at an angle of about 30° with the horizontal, where it terminated in a timber buffer about the height of the wheels of the mucking cars. The manner of operation was as follows: The flat car, without sideboards, having been loaded in the tunnel with the rectangular blocks in which the clay came out, was run

onto the elevator and hoisted to the level of the platform on top. Here it was pushed onto the inclined track above mentioned, and by its own weight dashed rapidly down, only to bring up short against the wooden buffer. The clay, however, being wet and very slippery, was by its own momentum carried beyond the car and dropped into a dump cart which had been previously backed into position. The empty car was then hauled back to the elevator by hand.

The concrete was mixed on top and taken down by the elevator, sometimes in regular concrete barrows and sometimes in the cars that were used for mucking out.

The average length driven for a shift during the progress of the work was seven feet, and the average cost per foot, exclusive of the first cost of the lumber and the cost of trimming the same to dimension, was about \$4.50.

DISCUSSION—TUNNEL AND CONCRETE SEWERS AT HARTFORD.

THE PRESIDENT: I am sure Mr. Clark would be pleased to answer questions on this interesting work.

MR. KELLOGG: I notice in the photograph, particularly, they used the collapsible steel forms.

MR. CLARK: That was in the Gully Brook system of the Homestead Avenue system, where it was used only on the arch.

MR. KELLOGG: I would like to know if they found they worked satisfactorily.

MR. CLARK: They worked very satisfactorily indeed. They had some difficulty in the Ann Street system, as I mentioned. The contractors ordered the collapsible steel forms, and then started in with the wooden ones. After the steel ones arrived they endeavored to use them, but it was difficult to collapse them and they had so much trouble with it that they finally gave up the use of steel forms and used the wooden ones.

MR. BURT: Might I ask, Mr. Clark, whether there were any contractions of the space that was excavated, any difficulties, special difficulties in tunnel work? Any narrowing of the section?

MR. CLARK: We had some difficulty, on account of the wetness and slipperiness of the material, in pressures from the side. I think they are evident in some of the photographs. The vertical struts on the side show quite decidedly the bending in

due to the enormous pressure from the outside, and although they caused some apprehension, actually they caused no difficulty in completing the work.

MR. BURT: Did you have special mining men?

MR. CLARK: My impression is that the men used on that were some that they got from New York. Is that so, Mr. Brewer? You can tell about that. Mr. Brewer was the resident engineer.

MR. BREWER: The superintendent was connected with one of the New York tunnels and he recruited his gang from men working down there. The gang was very efficient.

MR. BURT: What was the rate of progress?

MR. CLARK: About 7 feet at a shift, working two shifts a day.

MR. CLARK: I would say this form is the idea of Mr. O'Connor of the contracting firm, who is also one of our members. Perhaps he can explain its working better than I can. He very kindly loaned me this for exhibition.

MR. O'CONNOR: The steel form we found great difficulty in getting apart, but we got this form and used it and we found it very much more satisfactory. You can put it up in a few minutes, and you can collapse it and pull it ahead and use it over again. We found it a success. That is about all I have to say.

MR. CLARK: Just what was the difficulty, Mr. O'Connor, in drawing the steel forms?

MR. O'CONNOR: They didn't collapse enough to free themselves.

MR. JACKSON: We had that same trouble with the steel forms in New Haven; we couldn't draw them easily after the concrete had set. In fact, if they hadn't had an engine and a couple of tackle blocks on the job they wouldn't have been able to draw them at all.

MR. LEWIS: Was that because of the greater adhesion of the steel to concrete than wood?

MR. O'CONNOR: The steel form didn't collapse enough to cut away from the concrete.

MR. LEWIS: Then if the steel form was made with proper provision for collapsing, it might be used just as well?

MR. O'CONNOR: Just as well.

THE REINFORCED CONCRETE LOCOMOTIVE HOUSE AT WATERBURY.

By G. Milton Poley.

Included in the new modern facilities for locomotives of the New York, New Haven & Hartford Railroad at Waterbury, Conn., is a reinforced concrete locomotive or engine house. It is located at the junction of the Highland Division and the Meriden Branch, about one and one-half miles west of the new passenger station on the Western Division.

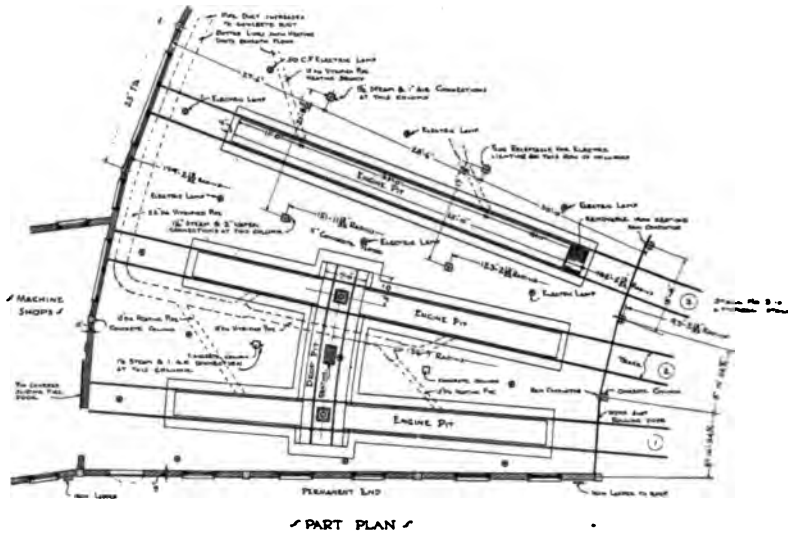
Although a reinforced concrete engine house is not a novelty, such construction goes far toward solving the many questions of maintenance, repairs and insurance. The corrosive action of smoke, gases and cinders upon exposed steel, galvanized iron, and even copper, prohibits the use of these materials to any extent, when exposed.

The engine house is constructed of ten stalls, each stall a segment one forty-fourth part of a circle, making an angle of about 8 degrees 11 minutes. One end of the house is permanent; the other may be extended to make an ultimate house of forty stalls, the space of four stalls being taken by the entrance and exit tracks to the turntable.

The turntable is the steel deck girder type and of such weight as to take the heaviest equipment.

A wing of shops is attached to the engine house, having necessary machinery for making repairs and also facilities for the use of trainmen. The shops cover an area 42 feet wide and 158 feet long.

The radius from the center of the turntable to the center of the inner circle columns of the engine house is 93 feet 6 inches. This arrangement will give ample space between the heads of the track rails at the turntable pit for cleaning out the snow and still maintain an opening of 12 feet wide at the entrance doors. The distance from the center of the inner columns to the center of the outer row of columns, in other words the width of the house, is 86 feet. It was thought that this dimension would



provide for the handling of different types of passenger and freight locomotives with the present clearance limitations and at the same time enable the dropping and renewal of the driving and trailer wheels under the locomotives at the drop pit without reversing either the locomotive or tender on the track, or opening the entrance doors during cold weather.

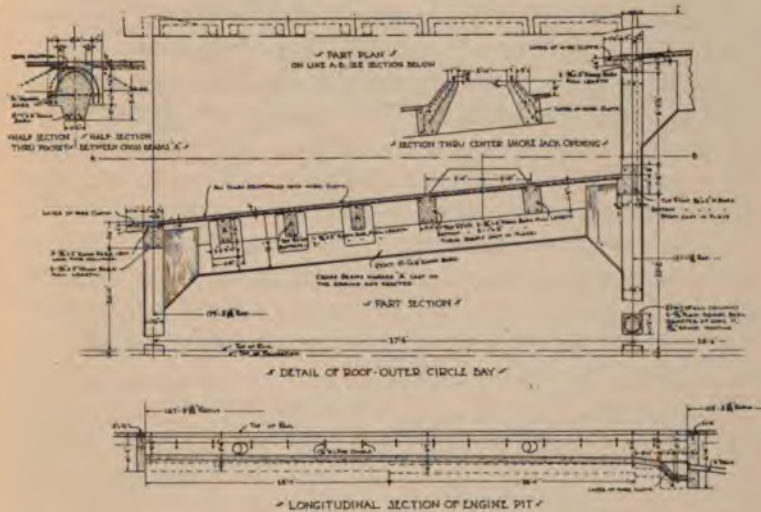
ENGINE PITS.

Each stall is provided with an engine pit, 62 feet long and 4 feet wide, to be used for general repairs to locomotives. The side walls are 2 feet thick of concrete, capped with yellow pine 5 inches thick, to provide proper support for jacking locomotives.

The track rails are spiked to 8" x 14" white oak stringers, parallel to and on each side of the pit. The capping pieces and stringers are held in place by 1 1/4" galvanized iron pipe dowels, imbedded in the concrete walls and projecting 3 inches in the wood. The dowels not requiring a hole through the wood pieces, prevent rotting to a large extent, which otherwise would occur on account of the large quantity of water used in washing and cleaning the locomotive boilers.

The floor of the pits is convex, of concrete, and slopes toward the inner circle, providing good drainage. The top of this floor

is 2' 6" below the top of the track rail at the outer circle end and 3' 0" at the inner circle end. A catch-basin is placed at the inner circle end from which a 6" cast iron drainpipe carries the water from the building. A wrought iron grating covers the catch-basin and the collecting sediment is easily removed.



DROP PIT.

The drop pit, to serve two stalls, is placed adjacent to the machine-shop, to facilitate wheel repairs.

In the drop pit at the center of each stall is a stationary jack, imbedded in the concrete and operated by compressed air. The jack lowers a pair of locomotive wheels to a small truck, running on a narrow-gauge track, from which the wheels may be jacked up and removed from the drop pit. When not in use, the drop pit will be covered with plank.

ROOF.

The roof is supported by four rows of columns, one row at the inner circle, two interior rows and one row at the outer circle. These columns are 13' 4" centers at the inner circle, 17' 8" centers at the second row, 21' 8" at the third row and 25' 7" at the outer circle; making spans, on the radial center

line, of 30' 0" at inner bay, 28' 6" at center bay and 27' 6" at the outer bay.

The roof of the center span is about 7 feet higher than the inner and outer spans, forming a monitor or lantern.

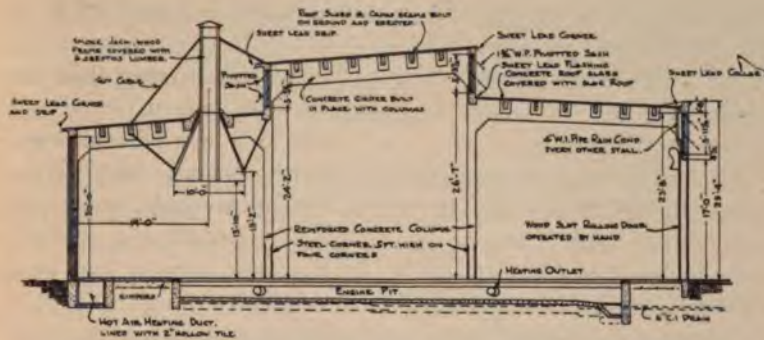
The columns, roof girders, beams and slabs are of reinforced concrete. All the columns, girders, beams forming faces of the building and the beams supporting the smoke jacks were cast in place. The cross-beams and roof slabs were cast on a concrete floor built on the ground especially for this purpose and then placed in permanent position. This method of construction, it was thought, would prove most economical and permit the most rapid erection. The longest portable beams were cast first; after setting given a coat of slaked lime, and the sides were used as a form in place of wood forms for the shorter beams. The roof slabs were cast in horizontal rows, wood forms being dispensed with after a first row was cast, thoroughly set and whitewashed. Very little trouble was experienced in removing the slabs or beams cast in this manner.

The columns, 14" x 14", are reinforced with six $\frac{5}{8}$ " square bars, hooped with $\frac{1}{8}$ " diameter hooping, laid $\frac{1}{2}$ " pitch, making a 11" diameter core. All of the columns, except the outer circle row, are protected on the four corners to a height of 6 feet with the Wainwright galvanized steel corner.

The girders supported by the columns are 2 feet wide at the top, tapering to 14 inches wide at the bottom. The depth of these girders for the inner or 30' span is 2' 10"; for the center or 28' 6" span is 3' 4", and for the outer or 27' 6" span is 3' 4". The bottom reinforcement is five—1" x 3" Kahn bars, with top reinforcement at supports. Reinforced pockets were cast on these girders to support the portable roof beams, which vary in span from 12 feet at the inner circle to 23 feet at the outer circle and in size from 6" x 15" to 9" x 18". The beams are reinforced at the bottom with one or two Kahn bars according to the span and one Kahn bar at the top. The top bar extends the full length of the beam to prevent breakage in erection.

The roof slabs are about 4' square and 3" thick, reinforced with wire cloth. After erection the joints between the roof slabs are filled with cement mortar.

All the concrete was machine mixed and composed of 1 part Portland cement, 2 parts sand and 4 parts of washed gravel, screened to pass 1" mesh and collect on $\frac{1}{4}$ " mesh.



RADIAL SECTION

ROOF COVERING AND FLASHINGS.

The roof slabs are covered with a 5-ply tar and slag roof.

The flashings and counter-flashings, except at the smoke jacks, are 6-pound sheet lead, zinc being used at the smoke jacks. A gutter, formed by the face beam at the inner circle, carries the rain water to a 4" diameter wrought iron pipe conductor at every other stall and connects to the 6" drain from the engine pits. This gutter will prevent the accumulation of ice in cold weather at the entrance doors. The roof of the center and outer bays slopes toward the outer circle and the rain water is allowed to drip off.

MONITOR.

The monitor, formed by the roof of the center span, answers a twofold purpose of light and ventilation. On each side are two horizontal rows of white pine sash, pivoted at the top with brass sash centers, that the bottom of the sash may swing out. The sash centers hold the sash in various angles from a closed to horizontal position. Ordinarily these sashes need be operated very little and will be opened or closed by hand from the roof. Two steel ladders at the permanent end of the building provide access.

SMOKE JACKS.

Each stall is provided with a stationary smoke jack, made in two parts, the stack and hood. The hood is 10 feet long and 3 feet 6 inches wide at the bottom, which will allow locomotives

being moved, as may be necessary for repairs, without causing the smoke and gases to be conducted into the interior of the house. The hood tapers to the stack, which is 2' 8" square, to insure free exit of smoke and extends above the monitor roof to insure good draft.

The smoke jacks are made of four 4" x 4" white pine corner posts, to which asbestos lumber is attached upon the outside with brass screws. The horizontal joints in the asbestos lumber are connected with cover plates of the same material, rivetted with brass rivets.

The jacks are guyed above and below the roof with four 1/4" diameter phosphor bronze cables, secured to the concrete roof beams.

A check damper of asbestos lumber is installed in the stack, weighted to close, and is operated by a brass chain from the bottom of the jack.

The sides of the jack extend lower than the ends, to better serve the smaller locomotives.

ENTRANCE DOORS.

Between columns of the inner circle to a height of 17 feet above top of track rail, are wood rolling doors, each provided with three vertical rows of wire glass slats. The glass slats are about 16 inches long and start at a height of 5 feet from top of rail.

The doors operate by hand with an endless chain.

The door of every third stall has a horizontal sliding wicket, which rolls up with the large door. The wicket doors provide access to and from the engine house at the inner circle without opening the large doors.

Above the entrance doors are two horizontal rows of pivoted sash, similar to those in the monitor.

OUTER CIRCLE WALL.

Enclosing the space between the outer circle columns is a brick wall, 12" thick. Centrally between columns in this wall is a large window, 15' 8" high and 15' 4" wide, of three sashes high and three sashes wide. The top and bottom sashes are hung with cords and weights, the center sashes being stationary.

The reinforced concrete face beam forming a lintel over this window, supports the roof. In case of an engine entering the house and not under control, due perhaps to a leaky throttle or air brakes, it can run through this window without damaging the roof supports.

The ends of the house are enclosed between the concrete columns with brick walls, to facilitate future extension.

FLOOR.

The floor of the house is concrete, 5" thick, crowned 2" at the radial center line of columns, sloping toward the engine pits. The floor is laid off in suitable size blocks, with sand expansion joints.

The floor over the main heating duct is reinforced with expanded metal.

HEATING.

An indirect heating system has been decided upon on account of the desirability of frequently changing the air of the house, thereby assisting in removing the smoke and gases.

A hot blast heating apparatus, installed by the B. F. Sturtevant Co., and designed to heat an ultimate house of eighteen stalls, was therefore placed between the ninth and tenth stalls. Any extension of the house over the eighteen stalls will require another heating unit.

The approximate volume of the house, for eighteen stalls, is 757,000 cubic feet and the fan is capable of handling 50,000 cubic feet of air per minute at normal speed, thus making it possible to change the air of the house once in every fifteen minutes.

It was thought more economical and advantageous to place the apparatus within the engine house itself and it is installed upon a reinforced concrete platform, the top of which is 10 feet 4 inches above top of rail, giving ample headroom below.

Owing partly to the limited space available for the apparatus the fan selected is of the multivane type. In this fan the runner is made up of a number of shallow blades, spoon-shaped to give maximum efficiency and large capacity in a small space. The fan is of the full-housed, vertical down discharge type, with the runner overhung on the shaft and is driven direct connected by a 9" x 8" enclosed, vertical center crank engine. The engine is

provided with a system of forced lubrication and requires little attention.

The air is drawn through a heater containing 8,220 actual lineal feet of 1" pipe, arranged in two independent groups of 4,110 feet of pipe each. Each group is built in 5 sections, each having 4 rows of pipe, so that the air will be drawn over 20 staggered rows of pipe.

The exhaust steam from the fan engine is utilized in the outside sections of the heating coils, while each of the remaining sections is independently connected to both an exhaust and a live steam main, running from the adjoining power plant, so that either exhaust or live steam may be used in the entire heater or a combination of both. Furthermore, any section may be cut out of service by a valve.

All of the air for heating is taken from the outside of the building, through an opening in the outer wall and by means of a galvanized steel connection on the cold side of the heater. A steel louvre and screen are placed on the outside of the opening. The inlet connection is fitted with dampers, so that one group of the heater coils need be used when the fan is running at the speed required to heat the ten stalls which are now constructed. By this means greater economy and efficiency is secured under the present conditions.

The heated air is discharged from the fan through a vertical duct connecting with the main hot air duct, beneath the floor, around the outer circle of the house. This connection is constructed of concrete, having walls 2" thick, reinforced with $\frac{3}{4}$ " steel channels and wire cloth. The main duct is also of concrete, the foundation walls of the outer circle of the house forming one side. Steel eye-beams support the engine track over this duct. On the two sides and bottom the duct is lined with hollow tile, 2" thick, faced with $\frac{1}{2}$ " of cement plaster, to prevent loss of heat by radiation.

The branch ducts to the engine pits are constructed of vitrified pipe below the engine house floor and two outlets are provided for each stall, so located as to effectively melt any ice adhering to the locomotive running gear. Each outlet, 15" in diameter, is provided with a "butterfly" damper, which may be set for any desired degree of opening. The damper is operated by rod, the handle of which is placed in a covered pocket beside the track, so as to be easy of access and offer no obstruction.

An automatic pump and receiver, installed beneath the heater platform, returns the water of condensation to the boilers in the power plant.

In designing and installing the heating system, particular care was taken to locate the apparatus so that, although a "wild" engine might run through the outer circle wall, it could not damage the heating apparatus.

SERVICE PIPING.

The engine house is piped with a hot water line, for washing out and filling locomotive boilers; live steam line, for exciting the draught of locomotives when firing; compressed air line, for blowing out flues, testing brake equipment, to operate jacks and pneumatic tools; a fuel oil firing system for locomotives, and a boiler blow-off line to convey the condensing steam to a tank, the hot water being used for filling the stationary boilers of the shops.

All of these service lines are suspended from the roof beams, along the outer circle wall and third row of columns. The branch steam and water connections and the branch steam and air connections drop down at alternating third row columns. The branch steam and water connections unite into a special "Y" fitting for making hot water.

ELECTRIC LIGHTING.

The building is wired for electric lighting and, on account of smoke and gases, all wiring is concealed. The wires are enclosed in iron pipes, placed in the concrete roof girders and beams. The same care was taken with the fixtures, which have no exposed ironwork.

About the center of each girder span, on the radial column center line, is placed a 50-candle power G. E. M. lamp for general illumination, each stall being controlled independently by a switch at the outer circle wall.

Four 16-candle power incandescent lamps are placed in pockets of the drop pit walls. A plug receptacle is placed at every second row column and at the heating apparatus platform for the connection of extension incandescent lamps. The plug receptacles are of special design, so constructed as to pull out before a strain sufficient to break the cord can be brought to

bear. This feature is of special importance in the engine house, where it often happens that the portable extension lamp is left in a locomotive through carelessness, and when the locomotive is run out either the cord is broken or the wiring torn out.

The house was built by contract, with the exception of the electric lighting, which was installed by the railroad company's forces, all under the direction of Mr. E. H. McHenry, Vice President, and Mr. Edward Gagel, Chief Engineer.

The reinforced concrete was designed under the supervision of Mr. W. H. Moore, Engineer of Bridges.

The writer is indebted to Mr. F. J. Easterbrook, Assistant Engineer of Construction, for many valuable suggestions as to the construction.

THE USE OF CONCRETE IN THE NEW ARSENAL AND ARMORY, HARTFORD, CONN.

By W. A. Payne.

In considering the use of concrete in the building of the new Arsenal and Armory on the roundhouse site, the subject is roughly divided into three parts:

1. Foundations,
2. Reinforced floor and roof construction, and
3. Decorative trimming of the exterior; and under these heads I will briefly state some of the problems presented and the manner of their solving.

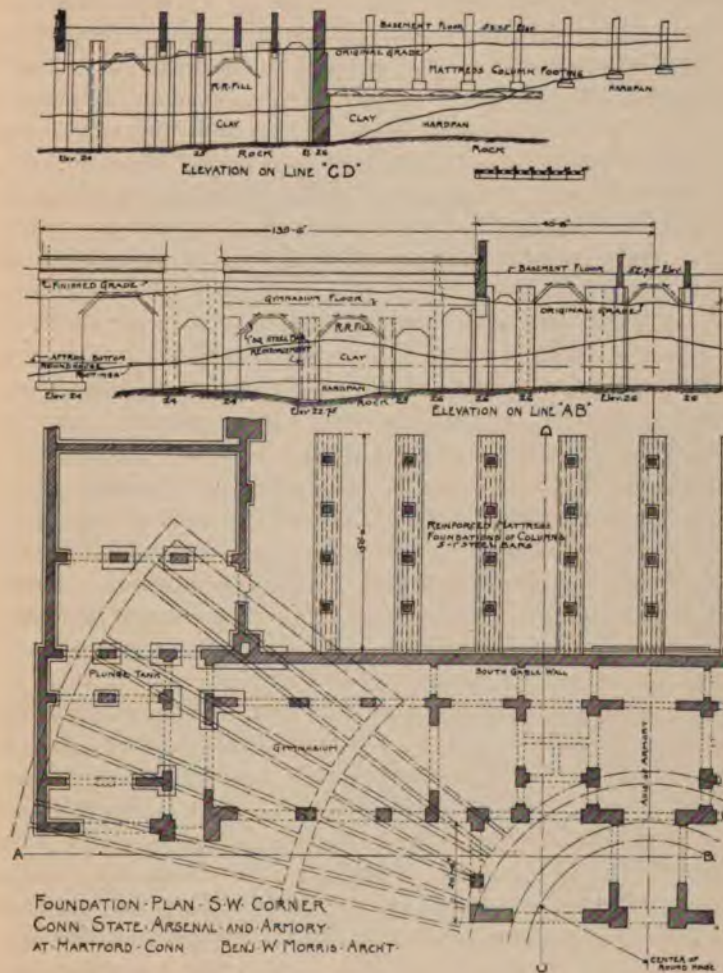
When the plans were originally drawn, it seemed inadvisable because of the uncertainty of the final selection of the site to make many borings to indicate the nature of the underlying strata and the drawings were made showing a depth and spread of foundation which would be necessary if hard pan were encountered just below the surface.

Experience has shown that the usual wash borings made are of little value. One case in Hartford indicated a general level of rock at an average depth of some 12 feet, whereas none was found above a depth of 20 feet below the curb. Test holes dug by hand are the best method of finding out precisely the nature of the sub-surface material and in the case of the Armory was the only method to insure accuracy.

The site having been finally selected and the contract awarded, a number of test pits were dug. The locality had been formerly occupied by numerous buildings and shops of the railroad, which had been removed when the ground was bought by the State and had been graded over to cover the unsightly foundations remaining. Below this the ground over the southern end of the Armory was composed of railroad fill of cinders, gravel, bowlders and miscellaneous material for an average depth of 12 feet, under which was found a thick layer of black clay and silt, indicating

the bed of a former filled-in pond or stream, under which was hard pan and rock at between 25 and 30 feet below the basement floor. Several tests were made to determine if the building could be safely built on the fill, which in most cases was good clean cinders, but finding the bearing capacity of only a little over a ton per square foot and the fact that the northern part of the building would rest on a firm bearing, determined the architect to carry the footing to hard pan or rock even at so great a depth below the basement. Here another difficulty was found in the location of the walls of the old roundhouse radiating over the southwestern end of the building and which rested on the soft clay stratum. The low one-story roundhouse might safely rest on this on large spread footings, but no part of the old walls could be used to support the new Armory of three stories. The old walls were very heavy and built of massive blocks of stone, which would be difficult to remove entirely. Nor could wood or concrete piles be driven to advantage, because of the nature of the fill and the lack of accurate knowledge of just where the old foundations existed. By process of elimination, then, the method shown on the diagrams was selected, that of building concrete piles or piers, extending to rock or hard pan, proportioned to the load they had to carry and placed as far as possible to avoid cutting into the old foundations. These piles or piers were reinforced vertically with steel rods and were connected several feet below the finished grade by arches, also reinforced, built with straight lines forming a soffit instead of a curve, to simplify form work. Elaborate figured drawings were worked out in the office for every wall and pier affected, with spread footings calculated in each case, for the guidance of the field force but not to be slavishly followed. As it happens, most of the piers rest on rock and the spread footings were used only in a small part of the work near the plunge tank, where rock was not found at the general level. The procedure was to dig and sheath pile a hole several feet larger than the pier, in which forms were built to the pier size and braced against the sheath piling. The rock was laid bare, picked, washed and scrubbed to give a clean bearing. After the concrete was placed and set, the forms were removed for re-use and the perfection of the pier work examined before back filling and removal of the sheath piling was permitted. The arches between piers were

treated in the same way, so that nothing was left to guesswork. In several places it was found necessary to alter the position and form of the piers, because of the location of the old founda-



tion walls actually discovered. In several cases also it was found advisable to build deep reinforced concrete beams between piers, omitting one which had been designed to be placed between and to carry its load on the beam.

This method of design and procedure, forced by the location of the old roundhouse foundations, was used throughout the head house, because of the economy effected over the building of continuous foundations of a depth necessary to reach a firm bearing for the whole structure.

The large south gable wall, however, was made continuous and extended to rock, because of its great height and consequent weight, which made the continuous foundation necessary to support this load. This wall, moreover, was increased 6 inches in thickness for every 10 feet in depth below the basement floor, to insure stability, and was made thicker toward the center as the slope of the gable above rose to the peak. Weep holes were also left to allow seepage through the wall.

The drill floor, which is at the first floor level, is supported on 207 columns, extending through the basement and into firm bearing. To have extended to rock at the south end would have necessitated great expense and labor to dig so many small holes. To overcome this, a form of continuous reinforced mattress was devised, resting on and extending north from the south gable wall to the firm ground and carrying four columns on each mattress. The effect of this was to spread the weight of these columns on the fill at a pressure of about 1 ton per square foot and to act also in a buttress capacity to the gable wall on the north side, the floors of the head house bracing this wall on the south.

In designing the size of piers a load of 13 tons per square foot was allowed on the concrete and rock and 3 tons on hard pan for spread footings. The concrete used in the foundations was 1-2½-5 mixture of Portland cement, sand and 1½-inch trap rock, into which in the large walls and piers were built pieces of rock and foundation stone taken from the old roundhouse and other buildings, forming cyclopean walls. The success of these foundations is attested by the fact that to date no cracks have been discovered in the superstructure, although the final weight is now obtained.

The Reinforced Concrete Floor Construction offers few peculiar or unusual features, but as this subject is not as yet so well known or standardized as steel beam construction, it may repay us to consider what was actually done in this case.

The specifications allowed the greatest latitude to the contractor in the choice of a system, and only stipulated the general assumptions of mix, stresses allowed in the material and the loads to be superimposed, and provided that the final plans be passed on by



the architect. The allowed stresses were 500 lbs. on concrete, 15,000 lbs. on steel, and the mixture was to be 1-2-4 of tested Portland cement, sand and $\frac{3}{4}$ -inch broken trap rock. The contractor selected the ordinary commercial square bar of mild steel and laid out the work after consultation with the architect

and his engineer, using the formula of $\frac{WL}{10}$ for slabs, $\frac{WL}{8}$ for beams and girders, the T for the latter for compression not to exceed five times the width of the beam or $\frac{1}{6}$ of the span.

By referring to the first floor plan the arrangement of beams and girders is seen, the irregular spacing being necessitated by the architectural requirement that beams should rest on the wall piers and be symmetrical in the rooms, as the ceilings are finished directly on the construction and not furred down. The slab thickness is a minimum of 4 inches for floors and 3 inches for roofs, although greater thickness is used in several places. The partitions are considered as permanent and their dead load is figured only for the actual position as planned. In most cases the beams rest on masonry walls, those of the roof being built on a slope to reduce the weight of grading material, and are placed so as to rest on and hold down the main cornice course of concrete stone and counterbalance the weight of overhang on the entablature.

The drillroom floor, however, is supported on the concrete columns above referred to, as shown on the plan. The columns are of square section and are not reinforced, as the load is all vertical. In either wing of the head house some interesting construction is necessary to support the floors of the company officers' rooms, there being three floors of these to two of the company parlor and locker-rooms. On the east side, the corner columns of the mezzanines carry the loads to the deep 40-foot plate girders over the squad drillroom, which are placed in pairs and under these columns. On the west, however, the only support under the officers' rooms is a brick wall coming directly under the center of the rooms, so that the floor beams had to be designed as cantilevers to transmit the loads of the corner columns to this center wall, as noted on the diagram.

The stairs throughout, of which there are nineteen separate runs of from one to four flights each, are all built of reinforced concrete with winders, platforms and straight runs, designed as slabs or with supporting beam strings, as the requirements dictate. In most cases the treads and risers are finished in cement as built, the wooden balustrade being fastened to the strings with bolts built into the construction.

The specification called for a concrete roof slab over the drill shed resting on the steel trusses and rafters. The pitch of the

roof is 30° and the rafters run from the gutter to ridge, 6 feet on centers. To have built forms between these and to have cast the concrete in place would have been a very expensive and difficult operation—as experience has shown on a roof of such steepness. An arrangement was designed whereby cinder concrete slabs, $2\frac{1}{2}$ inches thick, 2 feet wide and long enough to span two rafters, were cast on a specially cement finished bed on the drill floor and were hoisted and set in place, with joints staggered and held by beam clamps and angle knees securely attached to the rafters. The slabs were reinforced by a trussed wire mesh cloth and three $\frac{1}{8} \times 1\frac{1}{4}$ inch steel flats in each slab. After erection the slabs were pointed up and the 2×8 inch rectangular recesses left in the end of each slab were grouted and keyed together to form a continuous surface. Tests were made on these roof slabs before the scheme was finally accepted and they supported without permanent deflection a load of 175 lbs. per square foot, or five times the specified superimposed load.

All of the cement used in this reinforced concrete work was tested at the works and the fact that several lots had to be rejected for failure to comply with the specification shows the value of careful testing and supervision. The cars were sealed by the inspector and delivered at the site with unbroken seals, which were inspected by the State's representative before the cars were opened.

The Exterior of the Armory is built of coursed random range rubble ashlar of a beautiful granite, trimmed about openings and at numerous band courses and decorative members with artificial stone, manufactured for the most part at the site. Plaster models of each stone or type of stone were made, tooled and finished to the requirements. From these models sectional plaster moulds in reverse were made, carefully braced and arranged for easy removal after casting. In these the concrete stone was cast. Generally the mould was made so that the final exposed face of the finished stone would be cast downward. The mould was then carefully lined by hand with a composition of Portland cement, glass sand and hydrated lime, the exact proportion of which is the secret of the contractor. This lining, or rather the face of the stone, is about $\frac{1}{2}$ or $\frac{3}{4}$ inch thick, forming a veneer. The remainder of the mould was then carefully filled and tamped.

with an ordinary 1-2-5 mix of coarse aggregate. When the first set was had, varying in time with the weather and other conditions, the stone was removed from the mould and set aside face up and kept damp for several days until quite hard. Any imperfection of surface or line was patched soon after the mould was removed. The stone when well cured was then set, as is usual with natural stone. Large pieces with projecting members were reinforced with band iron or wire. Lintels and cornice members and the carved decorations were so treated and the bracket supporting the foot of the main flagpole has a reinforcement of a steel angle truss imbedded in it to transmit the load to the wall.

The central ornament at the top of the head house is constructed in fifteen pieces, but the large keys of the side and main entrance arches were cast in one piece.

The casting of the main entrance arch was a novel feat. The design calls for separate centers for the mouldings of the introdos and extrados, giving a varying cove mould between. The mould for the full arch was made in the shop by running the mouldings in reverse on the floor and then by means of thin boards representing the joints the members of the arch were cast on this full size reverse mould, insuring by this method an accurate matching and perfection of the stones.

One difficulty found in the use of made stone was the long time necessary for the curing of the pieces before they could be used, which in practice was hard to insist on, so that often the stones were set in the walls before thoroughly hard and the edges were apt to become broken. The general appearance, however, is very satisfactory, and when greater knowledge and facility is obtained, the use of manufactured stone will grow for many buildings where expense is to be considered.

DISCUSSION—THE INTERESTING REINFORCED CONCRETE WORK IN THE STATE ARSENAL AND ARMORY.

MR. JOHNSON: What was the purchase cost of this stone, compared, for instance, with limestone if it had been cut nicely?

MR. PAYNE: I have no real basis on which to answer that question, but it is very much less expensive.

MR. BELDEN: What brand of cement did you use?

MR. PAYNE: Atlas; that is, for the reinforced concrete work; and I believe Alpha for the concrete stone.

MR. BELDEN: Is the same cement used in the backing of the blocks?

MR. PAYNE: Yes, that was the intention.

MR. MURPHY: What particular tests were used at the cement works to determine the quality?

MR. PAYNE: For the reinforced concrete work they were tested by the Spackman Engineering Company of Philadelphia, on the specifications for the testing, standard cement specifications.

MR. UNKELBACH: Was there any allowance made for shrinkage? In casting the mould?

MR. PAYNE: No, none at all. Any slight shrinkage there would be in a little block of that kind would be taken up in the size of the joint, in the accommodation.

MR. EASTERBROOK: Was the reason for using cinder slabs on account of the lightness?

MR. PAYNE: Yes, that was so as to make the slab as light as possible to handle, mainly.

MR. EASTERBROOK: Do you consider the cinder slab as good?

MR. PAYNE: No, not as good, not as strong, but in our case the 2½ inch slab showing a superimposed weight of 175 pounds without permanent deflection shows a great strength was obtained. Of course the test was made; I have some figures of the average; it was on a continuous block over three supports, and each section was loaded in the center and the load arranged so that the concentrated load was in the center of each section, and that was equivalent to 175 pounds per square foot.

MR. UNKELBACH: What is the span of the four-inch floor slab of the main drill hall?

MR. PAYNE: That is about six feet. The slab throughout,—well, some of them are as much as eight feet. But that slab was ten feet. That of course is correspondingly thickened and the portion of reinforcement is increased.

MEMBER: What is the nature of the finished floor in that main auditorium?

MR. PAYNE: That would be a wood floor on sleepers. Double wood floor.

MEMBER: What is the object of the hydrated lime?

MR. PAYNE: The object of that is to prevent the moisture from getting into the stone and discoloring it. Also it gives a durable arris and is easier to manipulate, as to the veneer. I have a number of photographs of the concrete work here before they are finished with plaster, if any would like to see them.

MR. EASTERBROOK: What percentage of breakage did you have in the total number of slabs cast and the total number of slabs in position?

MR. PAYNE: Of the roof, you mean?

MR. EASTERBROOK: Yes.

MR. PAYNE: I can't tell that. Mr. Stammers, superintendent of the construction, might be able to tell. Mr. Stammers, can you tell the proportion of the breakage of the roof slabs that are cast on the drill shed floor, before they are put in the building?

MR. STAMMERS: I don't think we would have more than a dozen broken. There are about 2,058 slabs.

MR. FERRY: Put reinforcement on both sides of the slab?

MR. PAYNE: No, only one.

MR. EASTERBROOK: Did the slabs have a lap joint or square?

MR. PAYNE: Square joints, butt joints. The three flats that were put in were put in there to allow manipulation and raising to reinforce. Otherwise the wire mesh would be sufficient for the slab after it is set in position.

MR. EASTERBROOK: In the use of concrete for other buildings would the expansion require any reconstruction of the concrete in the building?

MR. PAYNE: No, none at all, the assumption being in a building that would be heated in the winter time, the temperature would not vary more than fifteen degrees, and the reinforcement is considered strong enough to overcome any temperature shrinkage of that amount.

MR. CLARK: I should like to ask if you embed large stone in the concrete as you go along?

MR. PAYNE; I think so, stone that is not too large and not placed too close together.

MR. CLARK: Of course in this case I suppose it makes a difference, but could you do it on soft ground?

MR. PAYNE: Well, not directly on the footing I wouldn't, unless where you have spread footings, but when you get up into the pier I don't think it is any detriment at all. Of course it all

depends on the proportion of the stone in the cross section of the pier.

MR. ANGUS: Don't you think it is a weakness?

MR. PAYNE: Well, these were not.

MR. ANGUS: I know where they have been used in a building in Wall Street, New York, and the corner of the building gave way. That is the reason we consider brick work a better foundation than stone work, because we have less perpendicular joints. I see you used quite a lot on the armory there.

MR. PAYNE: Yes, in the large piers.

MR. ANGUS: In the narrow walls.

MR. PAYNE: In the foundations. I don't think the proportion used is at all unusual or unsafe.

MR. ANGUS: There were quite a number of them. I saw in Cleveland they used them in a bridge there, and a structure used for a hotel.

MR. PAYNE: Well, experience is of course the best test. The foundations are complete and the building as it is finally completed, and no cracks have appeared.

MR. ANGUS: I know this building gave way where they used the large stone, though another where we had to put concrete all the way to get over quicksand, stood well; but where we put in the large stone, that gave way.

MR. PAYNE: Perhaps you had an unequal settlement.

MR. ANGUS: Well, it was put up with stone.

MR. PAYNE: You think, then, it was the failure of the pier and not of the foundation?

MR. ANGUS: In a large foundation the stone will stay. They wanted to save money and took the stone in the old building and put them in the foundation. I think they made a mistake.

MR. PAYNE: We tried to guard against that in this case.

MR. ANGUS: Over forty years ago concrete was in great use in New York City. It only lasted a few years because they didn't put it in right. Some engineers don't put it in right now, and it will only last a short time.

MR. PAYNE: Of course where you have spread foundations it is absolutely necessary to reinforce it. It is best to reinforce it with steel on account of the unequal bearing of the soil beneath, because no soil has an equal bearing anywhere.

MR. ANGUS: The trouble forty years ago was they didn't use the right material; the weather got hold of it.

MR. PAYNE: Were those mattresses reinforced?

MR. STAMMERS: Yes.

MR. PAYNE: Similar to these?

MR. STAMMERS: Yes. They were reinforced with five-inch rods.

MR. PAYNE: How thick were they? Same construction?

MR. STAMMERS: About eighteen inches thick.

MR. PAYNE: Same as the bottom construction?

MR. STAMMERS: Yes, only in an opposite way, because the pressure is from below, between the column supports.

STRAY THOUGHTS ON BRIDGE DESIGN AND MAINTENANCE.

By Herbert C. Keith, Consulting Engineer, New York.

In the critical examination, during the past few years, of more than a thousand bridges made of wood, iron, steel, plain and reinforced concrete and stone, the writer has not only been strengthened in some prejudices for or against certain forms of construction but has also been forcibly impressed with some facts of which he was previously ignorant.

The Anti-Tuberculosis League issues circulars with the alliterative truism that "dirt, dampness and decay promote disease." Similarly the engineer should constantly remember that dirt and dampness are also conducive to the destruction of his bridges. Of course we all know this; and we also know that the rule applies not only to wood, but also to iron and steel. Yet how unusual it is for proper precautions to be taken to prevent the collection of dirt upon our structures.

For instance, we often see stringers of I-beams or channels for the trolley tracks on a highway bridge with timber stringers only a half or quarter inch away for the planking. Thus a pocket is formed where dust and street filth will collect and hold the moisture, both to corrode the steel and to rot the wood. Why not set the timber two or three inches away? The apparent reason seems to be the saving of a few inches of shelf angles:—dollars sacrificed to save pennies.

Another common practice is the placing of the floor only one or two inches from the top of floor beams; in such a case, unless some preventive is used, dust will collect on the floor-beam flange, while with a space of six or eight inches the breeze would keep the top of the beam clear. Sometimes even a small strip of wood is laid on top of the floor beam, entirely preventing all possibility of the wind passing through, as if it were considered too much to ask of the planking that it should span a gap the width of the floor-beam flange. A still worse modification of this evil is where the under planking is laid with its top from one-quarter

of an inch to two inches (perhaps to provide a slight crown in the street surface) above the top of the floor beam and a pocket left under the top planking with no outlet whatever. A restricted depth for the structure may suggest such construction, but if the floor must be laid so close to the floor beam, the space may be filled in with asphalt or similar material, or at least a thick coating may be used to protect the steel.

Truss chords, portal struts and the bottoms of trestle posts furnish other common examples of pockets for the collection of dirt and its usual accompaniment of moisture; effect must follow if cause is present. Trough sections for chords should be avoided, and portal struts and similar members should as far as practicable be made so as to *shed* water rather than collect it. When a trough form is necessary, large holes should be drilled through the bottom to provide drainage:—small holes get stopped with paint or dirt. Pockets in bases of posts should be filled with rich concrete (not less than 1-2-4, or equivalent with gravel), put in very wet and the top finished with neat cement and the surface smoothed to drain properly.

Parapets of insufficient length or height may allow the fill to run over on bridge seats and around the steel or wood.

For the sake of a neater finish, the planking of roadway and sidewalks is generally made to fit nicely against webs and around stiffeners of girders. Original neatness is soon lost by the blistering of the paint, and later rust flakes under those blisters tend to the destruction of the bridge. It is desirable to leave a two- or three-inch air space next to girders if practicable. For bridges over steam railroads this might be objectionable, because of smoke and steam that would come through; in such case a beveled strip may be used to throw the dirt away from the girder.

The writer has many times had to break away mortar laid up around a timber trestle sill resting on a concrete or stone pier. Someone with good intentions had tried to protect the timber, with the actual result of holding the water around the timber until serious damage was done.

Timber stringers are sometimes laid with their ends surrounded by the fill, or with insufficient parapet to keep back the earth: in such cases decay follows very rapidly, for capillary action will draw the moisture along the grain of the wood much further and

more seriously than it can enter across the grain. It is sometimes well to smear the ends of timbers with tar or pitch. Spike-holes should be plugged, and the bark removed from piling. Except where teredo or limnoria are factors affecting their life, piling and timber posts decay far more rapidly near the top of the ground or the surface of water than either above or below this region.

In recent construction it is not often that two timbers are laid side by side close together, but frequently too little space is left between. It should never be less than an inch, and two inches is preferable; a pebble or straw may start the collection of dirt and the space become filled. Similar trouble may be found where two eyebars in a steel pin-connected truss bridge are laid close at one end and spread apart at the other. Either they should be laid close for the whole length (which is undesirable if it can be avoided), or spaced open for the whole length. If a V is formed, dirt is sure to collect and corrosion to follow.

It is also desirable to avoid contact of timber surfaces wherever possible. In timber trestles stringers are sometimes spaced by use of wood packing-blocks. Such stringers may be seen rotten for thicknesses of two inches each side of such packing-blocks and extending several inches longitudinally beyond the length of blocking, while elsewhere the timber is sound. The use of cast-iron separators would avoid this danger.

The durability of timber trestles is sometimes greatly increased by the use of cast shims between posts and the sills and caps, and on caps under stringers. Due care should be used in designing such construction lest other and greater troubles follow as a result. The tops of timber stringers are generally first to decay, because of moisture held between stringers and planking; a coat of tar or similar material, or even of paint, may add greatly to the life of both stringer and planking. In double planking, unless the lower layer is creosoted or treated with other preservative, it will rot rapidly; in highway bridges the top layer is likely to wear out.

Railroad bridges have been known to be planked for the express purpose of protecting the ties from the weather. Ordinary weather will be far more merciful to ties than the moisture that is sure to soak through the plank or between them and dry out only slowly. Of course a pitchy timber will keep out the moisture much better than more porous woods.

Perhaps it may not be amiss here to call attention to the fact that all woods suffer great reduction of strength before they reach such a condition as to be called rotten. Oak and chestnut suffer in this way, while still apparently retaining their original texture.

It is well known that cement, being alkaline, acts as a preservative for iron and steel; and, probably with this in mind, the ends of I-beam stringers are sometimes encased in abutments, perhaps composed of sandstone laid with a very thin mortar. The porosity of such masonry will do more harm than to balance the alkali of the cement. But even in rich concrete temperature changes will loosen the stringer in the masonry, unless the span is very short, and corrosion will result. In a certain very short stringer span now in mind, where the concrete is still sound, there is another trouble never elsewhere observed by the writer in anything like the same degree, though a suggestion of the same trouble has been observed: there is a decided reduction of section by rust on the whole periphery of the beam due to rain flowing down the face of the abutment.

As an individual the writer is one who would like to see the use of alcoholic liquor as a beverage stopped entirely if it were possible. As things are, he is content with a license law, but thinks the license fees should be higher and the proceeds used to ameliorate the injury done by the use of liquor sold under its authority. In like manner, as a bridge engineer who realizes that many of his fellowmen are fond of dogs, he would favor a high license for them and wishes that the receipts therefrom might be put into a fund for the maintenance of bridges. If it were all so used throughout this state, it would hardly begin to make up for the damage the dogs do to the bridges.

The value of paint does not seem to be perfectly understood by all men having the care of bridges, for sometimes it is used on timber where it would be better for the structure not to be painted. When ties on a railroad bridge are painted, the top is soon worn through, allowing the moisture to enter the tie, while the paint on the bottom, sides and ends prevents its quickly drying out.

But a far more frequent cause for complaint is the omission of paint from iron and steel structures, or the lack of thoroughness in doing the work. Some time ago a highway bridge was

examined in which the strength of the stringers and floor beams and also of the main girders, especially below the floor, was greatly reduced by corrosion; evidently the lower part of the bridge had never been painted since erection, while the upper part was rejoicing in a fresh coat. As considerable rust showed under the new paint, the recommendation was made that the bridge be thoroughly cleaned and painted, adding in capitals "especially below the floor." Examination a year later showed the lower part of the bridge still untouched and corrosion further advanced, but the upper part was still sticky with new paint, applied, however, over the old rust spots. Apparently the selectmen thought they knew too much to waste paint by using it where its beauty would not be seen.

As many of us know, it is hard to get painters to thoroughly clean off dirt and rust—in fact, it is often said to be impossible—but if metal is not cleaned, paint is worse than wasted that is put on over rust (unless the spots are small). If the skin of paint is broken, moisture will be held against the steel the longer to do its destructive work.

It may be asked what kind of paint is best. The writer has seen too many bitter paint fights to be willing in this connection to befog the issue by specifying any brand. Many paints are good if the structure is properly prepared and the paint properly applied under right conditions. At different seasons different paints might be preferred, but *always clean the steel*.

We hear a great deal said about the effect of electrolysis by leakage of current from trolley wires. Very likely much damage may be done to water and other pipes buried in the ground which may assist the return current to their own destruction; but bridges are different. It is doubtful if there are a dozen cases of recently destructive electrolysis in as many hundred bridges that the writer has recently examined; the electrolysis "gag" is enormously overworked. Of course these remarks are not intended to refute or even discuss the recent theory that all rust is electrolytic, generally with infinitesimal voltage; the term is used with the more common meaning.

While on the subject of rust it may not be improper to speak of the great superiority of iron to steel in this regard; the writer believes that if it were possible to obtain structural iron such as was used twenty-five years ago, we could well afford to pay

double the price of steel, in spite of the fact that steel has the higher ultimate tensile and compressive strength. If both were cared for according to our ideals, both iron and steel would have a durability almost inconceivable; but—alas for human frailty!—even men trained in just this line all their lives have allowed their own property to be neglected. If such men allow their own pockets to suffer so, how much more are bridges in care of untrained officials likely to deteriorate, especially in the hidden parts? With ordinary care—or neglect—good, well-puddled iron has a life several times as long as that of ordinary commercial structural steel. A bridge is in mind where, in order to strengthen the floor, steel stringers were added ten years ago to reinforce the iron stringers, then about ten years old. These steel stringers showing serious depreciation—or perhaps to further strengthen the floor—additional steel stringers were put in a few years later. The older steel stringers have little more than a rust streak left and the newer ones are in a much worse condition than the original iron stringers placed there four times as long ago. Of course it will be observed that this bridge is an unusually bad illustration of how bridges are neglected.

In this connection may we not ask why cast-iron pedestals should not be more frequently used for a girder or truss instead of shoes built up of plates and shapes? Cast iron will stand far more neglect than rolled or forged metal—either steel or iron. Such pedestals may require more metal to give equal strength, but dirt is sure to collect on bridge seats, especially if the ends are closed, and it is desirable to keep the more vulnerable rolled metal up out of danger. Of course in many places cast shoes would be out of the question. At times low-bearing blocks of stone set above the general bridge seat would be a happy solution.

We sometimes hear a large thickness given as the amount of paint on a bridge, because the calipered thickness of a member exceeds that given on the plans by the stated amount. It is not safe to jump too hastily to such a conclusion, for the fact may be that there is but little if any sound metal left. Rust swells to from three to eight times the thickness of the original metal of which it is composed; a little experience will enable one to judge, by the appearance of the rust flake, approximately what thickness of metal it represents.

In the United States there are thousands of bridges which have roller bearings in which the diameter of the rolls is from one and three-fourths to three inches, and in which the rolls have not turned for years. In fact, it is doubtful whether there are as many hundreds of roller bearings of less than three inches diameter which work as they were planned to do, as there are thousands with the bridge sliding upon the rollers. A small amount of dirt collects under the rolls, so that the sliding friction on top of the rolls is less than the force required to turn the rolls over the dirt. Or perhaps, instead of extraneous dirt, the obstruction is a thin film of rust on the bedplate, swelling and presenting an obstruction more firm than would be made by any dust the breeze would be likely to carry. At a certain highway bridge in one of the large cities of this state, the roller bedplate shows such a layer of rust nearly a quarter inch in height (representing about one-sixteenth inch of original metal). Large segmental rollers should be used instead of the smaller sizes of cylindrical ones.

Though many enthusiasts seem to consider concrete an ideal construction material in every way, especially when used in combination with steel, yet some more conservative (even if the propriety of calling them more careful be denied) engineers, see danger in its unrestricted use in all places, at all times and under all conditions. Probably it will be generally conceded that concrete is sometimes poorly mixed or placed, and that the resulting structure is unsatisfactory. It may also be acknowledged that when concrete (especially if lean and mixed rather dry) stands in tidal water and is subjected to freezing weather between periods of submersion, it is liable to disintegrate to a greater or less extent. A case is in mind where concrete which presents a good appearance above high-water mark has lost a large part of its surface below that level, with a maximum depth of hole of nearly two feet from the face of the masonry; this wall was built only seven years ago. Had this been the face of a reinforced concrete arch, the condition of the reinforcement may be imagined. The writer is of the opinion also that sea water filled with sewage and acids from factories and dyehouses might cause disintegration of concrete, even if the temperature never fell to the freezing point.

Perhaps, too, even the enthusiasts will admit that some reinforced concrete is designed by incompetent engineers, or by men with more confidence than engineering training or ability. Attention might be called to a reinforced concrete arch footbridge which was probably beautiful to look upon when it was built, with its marble tablets telling the name of the donor, but now its contours suggest the convolutions of a snake. It is to be hoped that its collapse will not occur when loaded to what was claimed as its capacity.

The writer has great respect for good concrete, both plain and reinforced, for well-designed structures, built in suitable locations and of materials well mixed and of good proportions; but in view of the large amount of reinforced concrete built where one or more of these conditions is not fulfilled, he believes that fifteen or twenty years hence reinforced concrete will be less popular than at present. He does not mean to say that the expected disfavor will be more reasonable than the present popularity.

Bridge substructures are generally considered such simple things, and are generally built of such durable materials that there is but little study given to them, unless there are unusual features connected with them, such as unusual size or occasion for artistic development. It is surprising to see how many abutments and piers are built right on the bed of the river, or the top of the ground, or nearly so, with no thought of settlement, or possible scour from the current, or heaving from the frost. Some are too thin for their quality, while others waste enough to make up; again, we see some plans with piling standing unsupported for a great depth below the platform, simply because their slimness was not appreciated because it was under water and out of sight. Riprap, either dumped in loosely or carefully placed according to the requirements of the particular conditions, would have saved many structures from failure. In waters infested by the teredo and limnoria, however, unless the riprap could be depended upon to silt up quickly and stay filled (which can be expected only in rare cases), the pileheads should be protected as well as stiffened by concrete. On the other hand, a short time ago, in the case of a certain bridge and its substructure, in water far from the sea and therefore without danger from these borers, the fact that the concrete about the pileheads was poor was urged to belittle the value of the property, and it was

claimed that expensive cofferdams must be built and the old concrete removed and replaced with new: the only value of the concrete in this case was to stiffen the pileheads, which was as well done by the existing concrete, poor as it was found to be. If there was danger of the old concrete washing out (which was not shown), the use of a little riprap would have saved thousands of dollars of what was proposed to be spent. Or in the original construction there might have been a saving by the use of riprap instead of concrete.

Perhaps it will be considered a digression, or a change of subject, but there are a few points in general design of which the writer would like to speak.

A large proportion of our bridges, even of modern build, are limited as to their capacity by "skimping" on the details. A few days ago a bridge was examined that had failed under load, the bottom chord of the truss having broken off square just because its real strength was only about half what might have been supposed from an outline drawing giving the sizes of the main members. The reinforcement for the middle panel stopped so close to the panel point that its strength could not be developed, and in the attempt to do so in a short distance, rivets were so crowded that the net section was greatly reduced.

Three thousand years ago the much-quoted wise man said, "Put not your trust in princes." Had the psalmist lived at the present time and had as large experience at bridge inspection as he did with royal families, he might now say, "Put not your trust in faced joints." To be sure, to err on the side of moderation rather than of exaggeration, it may be safely said that in light highway bridges not one case in ten, where the plans call for faced joints, has a satisfactory joint in the finished structure. Were it not for the fact that the efficiency of rivets is far in excess of what our ordinary working rules suggest, many bridges now doing good work would long ago have gone to their destruction.

Apropos of rivet and pin values; a bridge was taken down about twenty years ago in which, according to the ordinary rules for figuring them, certain floor-beam rivets were subjected to a shear of 80,000 pounds per square inch and a bearing stress of 130,000 pounds per square inch. The floor beam was cut apart to find the actual conditions and nothing abnormal appeared.

The same bridge had pins which, by the common method of calculation, would appear to be strained to 300,000 pounds per square inch. The pins were in good condition. This bridge was of iron.

Many bridges, especially drawbridges, have end floor beams of wholly inadequate proportions, because made only half as strong as the intermediate floor beams, while the actual load they may have to bear is usually even larger. Let us suppose the case of an end floor beam of a drawbridge; the stringers must be carried across the beam and overhang, to allow for the curve of the end of the draw plus whatever clearance may be allowed for the trusses. A car or road roller, or even an ordinary wagon, in entering or leaving the bridge, has one pair of wheels at the extreme edge of this overhang while the other pair is perhaps the same distance, or even less, the other side of the floor beam. The leverage may bring the whole weight (or possibly more) of the car or other vehicle upon the end floor beam; while with an intermediate floor beam, unless the panels are long, it is impossible to get as great a load. To the further disadvantage of the end floor beam, the vehicle in coming upon the draw span has to cross an opening of greater or less width, and strikes the edge of the overhanging floor a blow that must awe any engineer observing it and remove any surprise he may have had at seeing the condition of the floor beam beneath.

There is no claim that this paper contains any newly discovered facts; but all of us at times make mistakes when we *know* better than we *do*, simply because our attention is directed for the moment toward some other phase of the case. For this reason it is well occasionally to collect and repeat some of the well-known facts, that they may more surely come to mind when their use is needed. Some of these facts, too, may not have been sufficiently driven home to the minds of the younger engineers, to whom we look for so much of the designing of our works.

Neither would the writer claim that his work has always been free from the defects enumerated. Some of the facts were not pounded into his brain at the beginning of his career. In fact, some have been learned by experiences more or less bitter. He hopes, however, that his large observation of many and varied conditions has made him better able in new designing to avoid the mistakes he has seen.

Lest anyone should suppose that all the faults cited are found along the line of one system of railway with which some of the hearers know of the writer's connection, he would state that they are taken from several different states, some far distant from New England. And, as some of the city engineers of Connecticut know, some of the worst cases referred to are in bridges for which the railway is not responsible. Had there been the same intimate acquaintance with some other city engineers, they might have learned something about bridges in their charge that would have opened their eyes with surprise.

It has been difficult to obtain time to prepare this paper, much of which has been written on the train; but, if the bridges of Connecticut shall be the better for it, either in the care given to existing bridges or in the design of those to be built, the result will have well repaid the effort.

DISCUSSION—STRAY THOUGHTS ON BRIDGE DESIGN AND MAINTENANCE.

MR. SLOCUM (by letter): Mr. Keith's paper, along with that of Mr. Herman K. Higgins, before the Boston Society of Civil Engineers, on "Replacement of Bridges and Allied Structures," are invaluable contributions, mature evidence and digested information which the bridge engineer is fortunate in obtaining in so presentable and interesting form.

It is quite true that the life of a structure, whether railroad or highway, depends quite as much on the accessibility and spaciousness of all its parts, its freedom from small spaces and pockets which attract and catch dirt and moisture, as on the strains it safely absorbs. Could the designer have such a depth of floor as would enable him to avoid dirt-collecting intervals and joints that absorb drainage, a healthy and easily maintained structure could be produced, but as experienced designers know, such ideal conditions seldom obtain and probably never will, particularly in congested localities where a minimum approach grade for a crossing is demanded and where clearances for railroads demand an absolute minimum depth of structure. While much can be done in designing and constructing a more open structure, this too has its serious objections in allowing the exhaust and smoke to come up through the floor from the railroad below, causing

runaways and other consequent inconvenience and damage. The designer is generally compelled and feels it necessary, in order to keep the expense of heavy grades as low as possible, to bring his floor plank right down on to his floor beam, or just clear it.

It is hard work to impress town and city fathers with such details, when they have a grade crossing to abolish, when they are thinking more actively, and perhaps with good reason, of the increased cost in handling their decreased loads up tiresome grades.

The writer thinks that there is but little excuse for the construction of wood floors on any highway bridge in any locality at the present day. Present timber plank floors, much in vogue and in good practice but yesterday, two, three or four years ago, are giving way and must to more economical and permanent construction in solid masonry floors. The construction of piers and slabs or masonry arches can be accomplished as economically, if not cheaper, than old types, now plainly effete, and which are only of much concern to us because we have got to maintain them and not because we expect to build many more of them.

Mr. Keith's arraignment of the imperfections of steel and timber construction is a very strong argument for the use of materials of greater permanence. Moisture will always be collected and absorbed in timber work, because it is the nature of vegetable fiber. No artificial treatment of wood can make it as good as masonry.

Drainage grooves in concrete or reinforced concrete bridges can be provided and cut in proper and suitable places to shed water without entering, streaking or discoloring the structure, or rusting out the structure if it be partly steel. It has seemed to the writer that the problem of draining solid concrete floors is easier of solution than those composed of steel troughs.

The virtues of structural iron, of which we took advantage two or three decades ago, and now of historical interest, are not so pertinent to present construction as the study and investigation of latter-day materials, whose properties are now well established but which, along with steel in compression, and other materials of construction, much has to be learned.

The writer has made it his practice to visit and follow the structures he has designed, during construction, at completion, and again, as often as time permitted, after the structure had been

in use a year or more, and in this connection he thinks that the low setting of steel bridges is responsible for much unnecessary cost of maintenance, for the collection of dirt and cinders about the bearings making it difficult to keep the ends clean and as well painted as other parts. A step in the right direction would be to require all steel truss and girder bridges to be set on cast-iron pedestals, or bearing blocks, at least a foot high above the bridge seat, so as to have the structure up out of the dirt. The writer has in mind a heavy double track through a rivetted truss railroad bridge, on the design of which he spent considerable time, particularly the details of the bearings. This new main line structure, replacing an old and lighter structure, fitted onto the old masonry in rather too snug quarters, so that in a measure the close quarters helped the collection of cinders and dirt. The shoes and segmental rolls of this heavy structure rested on a grillage or nest of old rails as an additional sanitary precaution. Cinders and dirt concealed a good part of these bearings after a year and a half of use, with every evidence that the rollers, with polished arcs, did not roll but slid with changes in temperature; and after all, perhaps the bridge is serving its purpose just as well if you cannot see your face in the polished arcs of the segmental rollers. It is quite true that much refinement, spent in design, is out of place when compared with the care the structure receives when in use.

The paint question seems to be an endless one, requiring much patient investigation, with no immediate prospect of absolute and reliable conclusions. As to the superior advantages of one kind over another under so many varying conditions, the writer knows of no better advice than that given by an honored member of this Society, whose assistant the writer was for a number of years: "Try it on your particular bridge and watch it, noting all the circumstances of its application and conditions of maintenance."

To those of us who are apart and who are watching the progress of bridge construction, it will be generally conceded that open floors for railroad bridges and timber floors for highway bridges are fast being superseded by solid floors of reinforced concrete, or some combination of concrete and steel in which the steel is amply and permanently protected in doing its part of the work. Where the combination is used, the concrete should do

its share of the work. Steel sections figured as taking all the load and encased or lost in large masses of concrete, is hybrid construction which belongs to the uncertain or transition period of reinforced concrete, a period now safely past. To-day timber floors for highway structures and open floors for railroad bridges should be the exception rather than the rule. Slabs and arches of reinforced concrete and concrete are now replacing various forms of less permanent bridge construction, because they are more economical in first cost, if handled by an up-to-date engineering organization, and such construction is good for an indefinite period of time, requiring practically no maintenance. One of the many numerous cases in point, showing the tendency and progress of the science and practice of bridge construction, is that of the new Hopatcong cut-off of the Delaware, Lackawanna & Western R. R. This construction is through rugged country, where a large amount of bridge work was necessary and where concrete and reinforced concrete were the main construction bridge materials, the use of steel bridge work being comparatively insignificant.

The writer makes bold to say that the reinforced concrete arch will eventually be the graceful remedy for most of the usual ordinary bridge problems, and where an arch or a series of arches is not feasible, slabs, piers and beam construction will prevail.

It is not necessary to enter upon a discussion of the superior advantages of concrete and reinforced concrete construction, its first place in materials of construction is now well established. Its uncertainties, or what we are in doubt about, are rapidly becoming certainties and exact knowledge.

The profession, dealing mostly in exact knowledge, is not much concerned with the popularity of any material of construction, except in so far as the public safety is concerned. Popularity, as Mr. Keith infers, is transient and real values eventually become known.

In regard to the conservative and radical elements of the engineering profession, in their views of new materials of construction, our views are much the result of our personal knowledge and interests, and it is interesting to note the "line-up" and the results of the labors of the committees of our national engineering organizations who are investigating the new materials of construction.

MR. SHELDON (by letter): Many books and papers have been written treating upon the design of steel and iron highway bridges, and not a few upon preservative coatings, but little has been written and but a comparatively small amount of thought bestowed upon many of the vitally important points covered in Mr. Keith's valuable paper.

More especially with reference to the past, but also in speaking of the present, it is true that a very large percentage of all the iron and steel highway bridges built in this country are built from competitive plans submitted by structural steel contractors. These plans, as a rule, are drawn by thoroughly competent bridge engineers, who are instructed before designing the bridge, as to the load which it must be capable of sustaining, informed as to its dimensions and given all other necessary data. It then becomes the duty of such an engineer to design a structure as light as can be produced to meet the requirements of loading; for all other things being equal the lighter the tonnage the cheaper the structure of any one class can be produced.

If a $2'' \times 2'' \times \frac{3}{16}''$ angle has sufficient section to take the strain imposed, why should the designer substitute an angle of a heavier section, knowing that if he carried such a policy throughout the design that his company, under the close competition of to-day, would not have many light highway bridges to build? Yet $\frac{1}{16}$ of an inch deterioration through corrosion represents practically one-third of the total section of a member $\frac{3}{16}$ of an inch in thickness. Or in the case of a tension member, suppose that through a shop error a hole is punched slightly off center, then plugged and punched again; the effective section of an angle as small as 2×2 , whatever its thickness, is very greatly decreased when passed through the treatment just described.

Another defect in detailing frequently seen is that of connecting but one leg of a tension member to a gusset plate, or similarly of neglecting to splice the vertical legs of bottom chord angles in a truss, depending simply upon a lateral connection or tie plate to perform this office. Gusset plates at bearings of light rivetted highway trusses are frequently seen extending outward far beyond the base plate, having no milled joints and with perhaps not more than one-fourth of the rivets connecting the bottom chord member to the gusset plate performing the duty for which they were in existence. The fact that the friction between the

heads of rivets and plates is not considered when determining the number of rivets to be used at a connection, together with the additional fact that a rivet when driven has a diameter practically $\frac{1}{16}$ of an inch larger than its diameter as taken for calculation, has probably contributed toward the life of a great many rivetted joints.

A lateral bracing system forms no unimportant part of many steel superstructures. Yet many bridges are erected having the vertical legs of angle bracing in the plane of bottom flanges to floor beams, turned upward, thereby making a trough both to hold water and conduct it to the lateral connections and flanges of main girders and trusses at point of floor-beam connections.

Another factor in bringing steel for certain forms of bridge construction into some disfavor, coupled with the absolute disregard of parties having the maintenance of bridges in their hands, to the necessity of bestowing a reasonable amount of care and attention on a structure when once erected, may be found in the failure to thoroughly clean the steel in the shop under close inspection before applying the initial shop coat. The writer firmly believes that a cleaning and painting specification covering shop work far more rigid than is the present practice, understood by all parties concerned as a specification which will be enforced and a factor not to be forgotten by the contractor when figuring work, would result to the material advantage of the owner of the structure.

While, as stated by Mr. Keith, cast iron does not corrode to nearly the same extent as steel and hence might be used to some advantage in certain cases, I believe that its use should not be encouraged in other than the simplest forms of castings and never used where sudden or eccentric heavy loading may be imposed, the unequal cooling and contraction of the metal during manufacture, with the attendant liability to set up and develop strains within itself, as well as the liability of castings to contain imperceptible blow-holes, would seem sufficient to condemn its use in many instances.

Practically all of the points covered in this paper are doubtless well known and are not given with the idea that any new facts have been disclosed.

MR. ORROK: Mr. President, I think Mr. Keith is to be congratulated on the paper which he has given us to-day. I had

the opportunity, coming up from New York with Mr. Keith yesterday, to read over the paper. There were a few points which I noted at that time which he has brought out to-day, and I wish to say a few words about them.

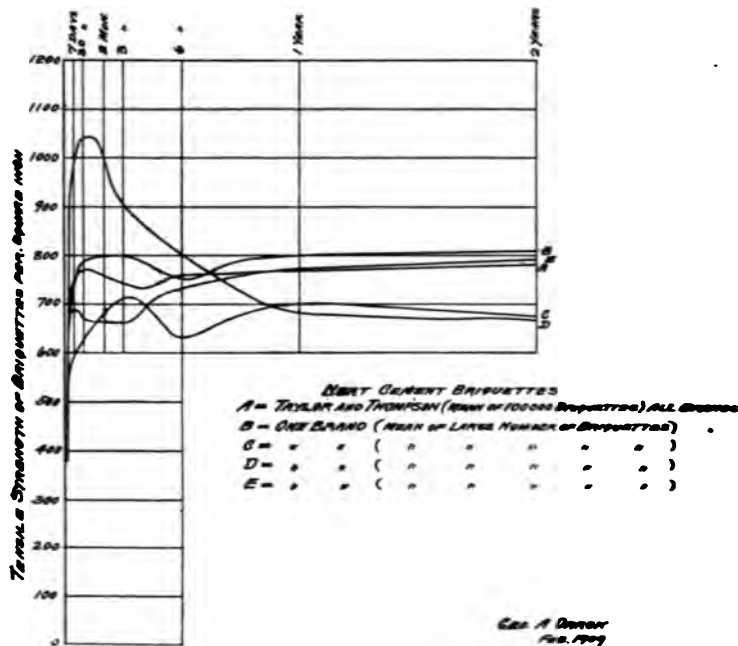
Mr. Keith rather dodges the question of paint. We had a little argument about that, but that is neither here nor there. I wish to call the attention of the Society to the use of fish oil, otherwise menhaden oil, in the preparation of paints for metal when exposed to the action of salt air. I don't know whether any of you have had occasion to use it, but I think if you have, you will see that it has a number of advantages over ordinary linseed oil. Fish oil is generally considered an adulterant of linseed oil, but in this particular case I have found it in my practice of very great value.

I want also to call the attention of the Society to recent experiments that have been made on the effect of manganese, silicon chromium, titanium and tungsten, in the making of steel where it is to be used for outside exposure. The ordinary steel that has gone into bridges in the past has been very largely Bessemer steel, made by the acid process and usually recarburized by ferro-manganese or ferro-silicon, and it contains at least $\frac{7}{10}$ of one per cent. of manganese. That is a little large for exposed work. I think that the steel that is made in the next few years will contain very much less manganese, very much less silicon and probably the addition of titanium, tungsten or vanadium in a very small amount, and we shall at last get a structural material which will be vastly better than the old wrought iron that Mr. Keith speaks of.

Mr. Keith makes a statement there regarding reinforced concrete with which Mr. O'Connor agreed. There has been a good deal of reinforced concrete put in in the last ten or fifteen years which will not stand the test of time.

I want to say a word about the reason of this. I have made a number of investigations on the effect of salt water on concrete, hot salt water. There are a number of power stations in New York in which the condensing water tunnels are large, ten or twelve foot diameter concrete tunnels, not reinforced. In two or three of these tunnels we have observed a deterioration which took place, in the cases under observation, in the first six months after the tunnel was put in service. We traced that effect to certain brands of cement used, or rather, not to certain brands of

cement but to certain analyses of cement, because we have had good cement of the same brands. I think that the cause of this is due to the fact that most cement manufacturers up to the present time have not taken sufficient care in the analysis of the aggregate before it goes into the kiln. I have found that variations in the analysis as large as five per cent. took place from day to day. The analysis of the cement itself is worked on what they call the hydraulic coefficient. They try to keep that within a limit of $1\frac{1}{2}$ per cent. That is much too large. The cement processes should be so worked that there would not be differences of over one per cent., when the analysis is made by the same man and with the same degree of care.



increase of strength, or rather the variation of strength of the neat cement briquette. These curves are very interesting. Some brands will in seven to fourteen days become exceedingly strong and then they will drop down to about two-thirds strength, and then increase at the six months' test and then drop off again. Some curves will rise up in kind of a seesaw, others will start in low and increase gradually, others will go way up high and then go down with a sweep. The final strength of all of these brands of cement is about the same; and as the making of the test was done by the same man and under like temperature conditions, and broken in the same machine with the same degree of care, we think that the tests are fairly representative. I also show a curve from Taylor and Thompson showing the mean of 100,000 briquettes covering a great variety of brands of cement.

As to the effect of ice on the face of concrete wall, I have had personally no opportunity of seeing concrete sea walls with a longer exposure than about seven years. Those that we have built get such exposure as we have in New York City, where there may be ice for perhaps ten or twelve days in the year. We have had no difficulty with those walls. Over in Massachusetts where they get much more ice, the difficulty has been very much larger, and there is a set of experiments being made over there now at the Charlestown navy yard from which we hope for considerable results.

THE PRESIDENT: I am sure we would be very interested to receive this information from Mr. Orrok on the effect of hot salt water on concrete, and it will make a very valuable addition to our published report.

MR. BELDEN: I would like to ask Mr. Orrok what was the trouble; he speaks of the variation of five per cent. in analyses of raw material during parts of the same day? What element in the analysis does he estimate causes the trouble with his concrete?

MR. ORROK: My opinion is that the analysis of cement may vary very widely in different brands of cement, due to the difference in the rock from which it has been made. Now each cement mill making cement from a certain kind of rock should find the analysis that gives them the best cement. That is no sign that the next cement mill half a mile away can use that same analysis. I don't think that is possible. The mills that I

have access to are more or less removed from each other, and analyses of the best cement in each of those mills are quite widely different. But the best results are obtained where they pick out that one analysis which serves best and then follow that right straight along in their manufacture. I know one firm that has been making cement now for the last three years in which the analysis has not varied but a trifle over one per cent. in that time.

MR. BELDEN: That is the total basis on the variation?

MR. ORROK: No, that is the hydraulic coefficient. But the limestone, clay and cement rock are so proportioned that the constituents are not more than one per cent. apart from the standard analysis.

MR. BELDEN: That variation occurred in the lime?

MR. ORROK: In the lime and also in the alumina and silica. If you have the opportunity yourself to get these facts, I think you will come to the same conclusion. I don't think it is possible to get a standard cement. I have been unable to myself.

MR. FURBER: I would like to ask the last speaker one question; that is, regarding the use of fish oil as a paint oil. That is not a new thing to me. I have heard it suggested before that fish oil was used for paint, but I always thought that it was a question of cheapening the product. Fish oil, as I understand it, is a non-drying oil and it forms a more or less sticky substance when used with paint, which of course is easily removed by abrasion. I would like to know what the virtues of fish oil are.

MR. ORROK: Menhaden oil, the oil of which I spoke, is rather higher in price—has been for the last five years—than linseed oil, and it is not used now as an adulterant. Menhaden oil is a non-drying oil, but the addition of dryers will bring it so it will dry in twenty-four hours; that is about the average time that ordinary steel preserving paints take to dry; so that where it has been used there was no trouble from the drying. I first saw its advantage down on Long Island, where they used it sixty years ago in the painting of wooden houses. One particular house that I have in mind was painted seventy years ago, and the paint, although not as fresh as it was when it was put on, yet is in very good shape. It was from that that I commenced to use it and have been quite successful in the minor works where I have had a chance to try it out. I have never had much bridge work outside, but I would like to see it used because our experi-

ence with it has been very good indeed. I wouldn't call it an adulterant.

MR. FURBER: Does it make a hard surface or is the surface soft?

MR. ORROK: It is somewhat flexible, as a linseed oil paint will be. It doesn't dry out hard; it makes a very good paint. There are some of the air-blown linseed oils that act in a similar manner; "Lucol," which was used on the Brooklyn bridge, you may remember that.

MR. KEITH: Before the discussion closes I would like to repeat, lest it might not be sufficiently observed, that my reason for not saying anything about paint is not that I haven't ideas on the subject, for I have pretty positive ones, but I did not wish to beg the issue that I was making, which is the use of the good paint properly applied. And with regard to the steel and iron, I was referring to the commercial steel of the present day and the commercial iron of twenty-five years ago. Also with regard to the popularity of reinforced concrete, I was not saying that the predicted loss of popularity was any more reasonable than the present undue popularity which it has; simply that the failures are going to make the pendulum swing the other way.

MR. HILL: The hour is late and I will not take the time now to discuss this paper; I simply wish to express my appreciation that Mr. Keith has been able to capture his stray thoughts, and given us the benefit of them this morning, because the suggestions that have been made are admirable.



EDGAR CLARK.

In Memoriam.

Mr. Clark became a member of this Association in 1887, and later an honorary member. He was born in Putnam, in this State, March 26, 1824, and died in the same town April 13, 1908, at the ripe age of eighty-four years. He graduated from Bacon Academy and taught school in Colchester and East Hampton, occupying his spare hours in the study of civil engineering.

Beginning in 1849, he was employed for some time in chemical work in Providence, followed by employment as draughtsman in a Boston office. Indoor work proving prejudicial to his health, he

entered the employ of the New Jersey Central Railroad Company as a civil engineer. He laid out the town of Cambria and the mills of the Cambria Iron Company.

After considerable time spent in mining engineering, in 1857 he returned to Putnam and became assistant engineer under William Lester of the Boston, Hartford & Erie Railroad. Later he opened an office in Putnam and for many years was the principal civil engineer and surveyor of Windham County, doing a great variety of work required by manufacturers, real estate owners and others.

The writer was in his employ for about a year in 1872-3 and enjoyed the benefit of his library, his experience and his kind instruction and advice. He was much interested in scientific matters and especially in astronomy. For many of his last years such studies occupied much of his time and active mind.

C. E. CHANDLER,
Committee on Necrology.

ABSTRACT OF THE PROCEEDINGS

AT THE

TWENTY-FIFTH ANNUAL MEETING

OF THE

Connecticut Society of Civil Engineers.

Convention called to order at 11.10 A. M., in Pythian Hall, Hartford, President Edward W. Bush in the chair.

It was voted to accept the minutes of the previous meeting as printed in the annual report.

Secretary Jackson read the report of the Board of Direction, as follows:

REPORT OF THE BOARD OF DIRECTION.

At a meeting of the Board of Direction held in North Sheffield Hall, New Haven, February 11, 1908, the resignation of H. D. Card was accepted. The resignation of C. M. Ingersoll was tabled. The following members were dropped from the rolls: O. F. Cooley, H. DeB. Forbes, Edwin Jones, Frank Loomis, E. J. Noble, W. C. Watson, G. D. Young. The following applications for membership were approved: Jonathan H. Child, Wallingford, Conn.; Matthias W. Denman, Springfield, Mass.; Chas. A. Sibley, St. Louis, Mo.; Charles P. Waterman, Bristol, Conn.; E. C. Webster, New Haven, Conn.

At a meeting at the Asantawae Club, July 17, 1908, the Secretary was instructed to write the Arkansas Society expressing the Board's approval of House Bill No. before last Congress. It was voted to hold the summer meeting at Lake Compounce, the arrangements to be left to a committee appointed by the President.

At a meeting August 12, 1908, at Lake Compounce, the following applications were approved: George B. Allen, Hartford, Conn.; Albert S. Brainard, East Hartford, Conn.; Robert J. Coe, Terryville, Conn.; Joseph W. Cone, Greenwich, Conn.; Fred C. Hunter, Waterbury, Conn.; Malcolm Merritt, Port Chester, Conn.; William H. Miller, Waterbury, Conn.; Julius Sterling, New Rochelle, N. Y.; Charles F. Taylor, Windsor, Conn.; Frank W. Wright, Putnam, Conn., for full membership and Warren P. Bristol, Hartford, Conn., for associate membership.

At a meeting January 8, 1909, in the City Hall, New Haven, the ballots for nominations for officers for 1909 were canvassed with the following results :

President, Frederick J. Easterbrook, New Haven.

1st Vice President, Shepard B. Palmer, Norwich.

A. William Sperry, New Haven.

2d Vice President, Charles A. Ferry, New Haven.

Sheldon E. Miner, Greenwich.

Secretary and Treasurer, J. Frederick Jackson, New Haven.

Board of Direction, Edward W. Bush, Hartford.

Charles F. Chase, New Britain.

Henry J. Kellogg, New Haven.

The President appointed Messrs. Kellogg and Easterbrook a committee to audit the Treasurer's books and accounts. The resignations of C. T. Bissell and C. M. Ingersoll were accepted. The names of A. C. Heitman, R. G. Pike and H. W. Sperry were dropped from the rolls. It was voted that the annual meeting be a two days' session, that it be held at Hartford, the arrangements to be left to a committee to be appointed by the President.

Signed,

EDWARD W. BUSH,

HENRY J. KELLOGG,

J. K. PUNDERFORD,

CHAS. F. CHASE,

F. J. EASTERBROOK,

GEO. K. CRANDALL,

Board of Direction.

Attest:

J. FREDERICK JACKSON, *Secretary.*

It was voted to accept the report and print the same in the Proceedings.

Report of the Secretary was read by Mr. Jackson, as follows:

REPORT OF THE SECRETARY.

To the Officers and Members of the Connecticut Society of Civil Engineers;

Your Secretary respectfully submits the following report:

In June, sixteen hundred copies of the twenty-fourth annual proceedings were printed and distributed to the members, to those societies with whom we exchange, and to different libraries and institutions of learning.

The Society held one additional meeting on August 12, a trip to Lake Compounce, where the members amused themselves playing ball, and enjoyed a trip to the filtration beds of the city of Bristol, sitting down to a sheep bake at the close of the day.

The Secretary has during the year attended the different meetings of the Board of Direction; has had printed and distributed notices of the different meetings, bills for dues and advertising, and the ballots for

nominations and election of officers. The canvass for nominations resulted as stated in the report of the Board of Direction.

During the year seventeen new members have been elected, one honorary, fifteen active and one associate; five active members have resigned, nine active and one associate have been dropped, and one honorary, Edgar Clark of Putnam, Conn., has died.

The membership on February 8, 1909, is as follows:

	Feb. 10, 08.	Elected.	Resigned.	Dropped.	Died.	Feb. 8, 09.
Honorary	12	1			1	12
Active	264	15	5	9	0	266
Associate	8	1	0	1	0	8
Total	284	17	5	10	1	286

Voted to accept the same and print in the Proceedings.

Report of the Treasurer read by Mr. Jackson, as follows:

REPORT OF THE TREASURER FOR THE YEAR ENDING FEBRUARY 8, 1909.

J. Frederick Jackson, Treasurer, in account with the Connecticut Society of Civil Engineers.

RECEIPTS.

To cash on hand, February 13, 1908	\$119.36
Received from advertisements, 1907	17.00
Received from advertisements, 1908	554.45
Received from back dues	141.00
Received from dues 1908	468.00
Received from dues 1909	222.00
Received from sale of dinner and lunch tickets	311.00
Received from sale of proceedings	5.60
	\$1,838.41

DISBURSEMENTS.

By Cartage	\$ 8.50
Expressage	60.25
Freight	18.44
Expense, annual meeting	258.15
Postage	.93
Printing, stationery and supplies	1,068.44
Rent of P. O. box	4.50
Engraving	27.47
Services of stenographer	40.00
Summer meeting	107.00
Transportation	1.55
Cash on hand, February 8, 1909	243.18
	\$1,838.41

February 6, 1909.

Having this day examined the books and accounts of the Treasurer we hereby certify that they are correct and that the balance in the bank agrees with the same. Also that the above is a correct statement.

F. J. EASTERBROOK,
HENRY J. KELLOGG,

Auditing Committee of the Board of Direction.

Voted to accept and print in the Proceedings.

Mr. HILL of the Committee on Stream Measurements said: Mr. President and Gentlemen, the committee on measurement of streams and special legislation in relation to the assessment of damages for taking the water for public water supplies, have talked the matter over individually and informally among themselves, and also had a meeting this morning in relation to the matter. The chairman of the committee, Senator Brinsmade, was obliged to go to the Capitol, but the committee decided that it is very questionable whether any special legislation is necessary or practical at the present time. There are other matters in relation to it which may cover the ground, and the committee would respectfully beg leave to report progress and that the matter be continued.

I would like to say personally that I appreciate very greatly the services of our fellow member of the committee, Mr. Chandler, for the excellent manner in which he has rearranged the measurements of streams already taken, and put them in very convenient form for the use of engineers. I think all engineers who have occasion to use these measurements will appreciate that work. But in the present case the committee simply asks permission to report progress and to be continued.

Report accepted and committee continued.

The following members were elected, unanimous consent being requested to include the name of Nathan J. Gibbs:

For active membership: Gardner G. Riggs, Waterbury, Conn.; Frederick G. Patience, New Britain, Conn.; George A. Orrok, Flatbush, New York; Carroll A. Campbell, West Hartford, Conn.; George B. McConnell, New Haven, Conn.; James L. McElroy, Bridgeport, Conn.; Rawlins Lowndes, Waterbury, Conn.; Everett W. Lewis, New Haven, Conn.; Andrew A. Canfield, Bridgeport, Conn.; Richard L. Saunders, New Britain, Conn.; Rodney B. Miller, New Haven, Conn.; Nathan J. Gibbs, Norwich, Conn.; Remsen B. Cole, Jr., Waterbury, Conn.; Herbert V. Olds, Hartford, Conn.; William H. Kershaw, Bridgeport, Conn.

For associate membership: William F. Hickey, Boston, Mass.

ADDRESS OF PRESIDENT EDWARD W. BUSH.

For twenty-five years this Society has lived, grown and prospered and the annual meeting this year may well be considered the "Silver Jubilee" in its history. The question has long since been answered whether or not there is a need in Connecticut for such a society as this. Those few civil engineers who organized the Society in 1884 were not mistaken and they

started an organization which has been of inestimable value to its members and also to the State of Connecticut as well.

This is the age of rapid changes and we no sooner get one set of engineering problems settled than others appear with mushroom-like rapidity to perplex the engineer and keep him guessing. For example, after many years of agitation, discussion and experiment, macadam roads have come into general use. Now the swift moving automobiles are rapidly tearing them to pieces and the road engineers are called on to invent a road surface that will stand the effects of auto travel. Various experiments in road building and pavements have been tried in different cities and parts of the state in the endeavor to secure a lasting road surface that will be durable, dustless, and will withstand auto travel; and it is hoped that members of this Society will soon present papers on this subject, so that the results obtained in one locality may become known and available to other parts of the state.

There is another subject that I would suggest that the Society consider, that is, the present manner in which the land description survey is written in most deeds. Probably all members of this Society have, at one time or another, had occasion to try and locate land from surveys given in deeds and have been unable to establish a single corner without recourse to other and better descriptions of abutting property. It would seem that we have made no progress in the past two hundred years in the way most deeds are drawn, and there is room for a much needed improvement here. The lawyers will probably claim that the drawing of deeds is lawyer's work. So it is, and an examination of some deeds will prove that they, and they alone, did the work. In looking up a boundary line some months ago I found six deeds of abutting property owners, each survey describing the property as being bounded by the highway and land of the various neighbors, without a single distance or angle in the entire tract and nearly all the fences gone. It may be that for good and sufficient reasons the present custom of permitting the recording of deeds that describe land that cannot be identified, shall be continued; but the subject could be investigated by a committee of the Society, if it so desired, and if after due consideration it was thought best to endeavor to get the present law amended, I am sure the influence of this Society would have great weight in the deliberations of the General Assembly.

The past year has been one of financial depression which has had its effect on the amount of engineering work done, but we apparently have now passed the ebb tide and can confidently again expect the return flood tide of prosperity. One would think, by the many replies of members, that they "didn't have the time," when approached for an engineering paper, that the "hard times" had not struck the members of this Society at all.

The summer meeting of the Society was held on August 12, at Lake Compounce, attended by seventy-five members and guests. A visit was made the sewage filtration plant of the town of Bristol. The annual ball game between nines captained by Messrs. Easterbrook and Jackson was played and the question of supremacy is still in doubt, as the losing side claim they played against ten men.

You will notice in the report of the Treasurer that there has been a change from the custom followed heretofore, in the manner of presenting the financial condition of the Society. As the bills for dues are paid in advance, a considerable sum is received just prior to the annual meeting, and is later used to pay for printing the annual report. This fact should be taken into account when considering the financial condition of the Society. Last year the Society met with unusual expenses in printing the annual report, due to the expensive inset illustrations of one of the papers; also, the book was a large one. We started the present year with a deficit. The report printed this year was not as large and we were able to obtain more advertisements, so that the receipts this year will exceed the disbursements by about two hundred dollars. During the year the Board of Direction, contrary to a usual custom, have made no appropriation from the funds of the Society for the expenses of this meeting or the meeting held in August.

At the last annual meeting the Secretary was authorized to edit and condense the printed report of the meeting. This change, besides decreasing the printer's bill, has been a most beneficial one, the appearance of the book being greatly improved by it. I wish to congratulate the Secretary on the excellent manner in which he has issued the annual reports from year to year. Our publication is a model of its kind and this is due to the careful and exacting work of our Secretary.

In closing, I wish to extend hearty thanks to my associate officers and to all committees and others who have assisted by their counsel and services in the affairs of the Society during the past year.

Voted, that the address of the President be accepted and printed in the annual report.

PRESIDENT: Has anyone anything to offer in the way of new business?

MR. BUNCE: Mr. President, I would like to have your idea as to whether we are to take up any of these recommendations at this meeting or whether they should be referred to a committee, for instance, to consider the advisability of appointment of committees at a later period at this meeting?

THE PRESIDENT: I might say that the Society could discuss the matter now if they wanted. I have talked with two or three members of the Society who are interested especially in the work of filing deeds, and those that I talked with thought that the subject might be investigated by the Society. Unfortunately Mr. Washburn, who was one of those I talked with, is out of town to-day.

MR. BUNCE: It seems to me that there are two suggestions in your annual report that are very worthy of consideration. I think that, first, the suggestion you make in reference to road building would be a valuable matter for members of the Society who are in that work, and over various parts of the state, to take up and give us some suggestions derived from the experience which they have had. I think that would make a very valuable addition to the literature of this Society. And I think also

that your suggestion in the matter of deeds of property is very important. It is curious, but only yesterday I was called on to give the lines of a piece of property in the city in order that a sale might be made. I found a description something like this: The south line running through the center of a brick block, and the same line produced to its eastern terminus; bounded east by the gentleman who formerly owned it, south by another, north by a three-foot pass-way on the north side, and west by street.

Now it so happened that the property next to that some years ago I had made a survey and map of, and the man who was dealing in this property had bought that property and had the map. If it hadn't been for that, I never in the world would have been able to determine that line. I followed that description back as far as 1871 and found no difference at all. The deed had been copied again and again and again.

Now it has come to me in my practice that quite frequently lately when a lawyer wants to make a deed for a man he has asked me to furnish him an engineering description of the property, which of course I am always very glad to do for the sake of the poor fellows that are coming after me and will have to look up that property again sometime, and I think it a very valuable suggestion in your report that something in that line should be accomplished so that the careless deeds—and three-quarters of them at least in my experience are careless—can be rectified. In many cases if a man had to go into court and swear that he knew positively as to where the property lines were I doubt whether he would be willing to take the responsibility.

MR. PUNDERFORD: I think the suggestion you make is a good one. In the case of rights of way, a company in looking up the ownership of parcels of land has often found it difficult to obtain satisfactory measurements. Thursday, the 11th, is the last day, unless they extend it, for the introduction of new business in the present General Assembly. Unless something is done before then you will have to wait two years for legislation. It seems to me practicable for the Chair to appoint a committee of three, say, who can before Thursday frame some form of bill, not one that they will be satisfied with or the passage of which will be desired, but that will give them a chance to have that bill assigned for a hearing, say a month or two months later, when they will have had time to frame a proper substitute bill. If you merely put in a bill covering the subject now, later you can revise that one before it is called for a hearing, and I think get legislation this year. Otherwise you will have to wait two years. And I move you, Mr. Chairman, that the Chair appoint a committee of three to prepare a bill and if the Society thinks it practicable introduce it before Thursday, unless they extend the time, after which time they can have a month or two months before they ask to be called for a hearing to get the bill in shape.

THE PRESIDENT: Mr. Punderford, I think if the Society is to take this subject up, they would gain by letting it go over two years. If we appointed a committee to report a bill or report to the Society at the next annual meeting, and possibly have advance notices printed so that

the members of the Society would have one year to discuss it and to make up their minds how they want the bill drawn, it seems to me it would carry more weight with the legislature as being the action of the Society after two years of careful consideration. And the time is so short I don't think we could arouse enough interest in the Society to attend the hearing and get people interested in this thing. Now the assessors throughout the state would be very glad of any change. They are not able to find the land now, and when property is transferred, bounded by the neighbors, they don't know the size of the property, and I understand that most of the assessors object to the present survey of land—the present descriptions, just as much as the engineers do.

MR. PUNDEFORD: My impression was, Mr. President, that we have here, I know, some members, from my personal experience with them, whose competency could be relied upon to draw a proper bill, and if that bill fails in its completeness it could be amended at the next session. I merely make that as a suggestion, rather than putting the matter off for two years. I would be glad to hear an expression on that. I don't believe in too much haste, but there is another policy—of going too far in the other direction. I make the suggestion in order to get the matter before the meeting, as I think it is one of importance.

MR. BROWN: Mr. President, in Massachusetts we have the same difficulty—and will it not always be so, due to the fact that a person in transferring property does not care to go to the expense of having a survey? He can have a good survey made; the lawyers know that the descriptions should be made before a deed is passed, and they will sometime recommend it to their clients, but the client frequently hardly feels like undertaking the expense.

MR. FERRY: If we could legislate to make people wise it would be very nice, but we can't do that any more than we can legislate to make them good. There is reason enough for this action. I ran across a deed yesterday that has Mr. Bunce's deed beaten to a frazzle, as President Roosevelt would say. It read something like this: Commencing at the southeast corner of the land hereby conveyed, said point being 400 feet back from the shore of Long Island Sound, thence south $47\frac{1}{2}$ degrees east, 100 feet southwesterly along land of the Laurel Beach association. That is to say, it started at the southwesterly corner and then ran southeast, southwest.

Another case I ran across awhile ago was a tract of land that had been transferred, I think, five or six times in two or three years. It happened to be on a corner formed by the intersection of two streets, and in those half dozen times three times they located the lot on three of the four corners of the street. That illustrates what lawyers can do when they sit up nights, and devise ways for describing property.

THE PRESIDENT: The motion is that a committee of three be appointed by the Chair to prepare a bill to be introduced into the present session of the legislature?

MR. PUNDEFORD: That was merely for discussion, simply to put the matter before the house. I know it is a short time, but I am confident there are members here who from their experience can frame a bill

which would certainly be some advance upon the present methods. It can be introduced before the expiration of the time of introduction of new business, which is the 11th, unless they extend it. That bill then can be worked upon for a month or two months, submitted to other members of the Society if they see fit, and then called for a hearing. I don't know that that is the best course; I merely put it before the Society for discussion. If you think that too quick action, well and good. I thought if we could save two years it was a good thing to do.

MR. BURT: I rise to remark that this subject relates to questions which the man in city engineering practice is often called upon to answer with certainty; also is a subject which this Society could well take up. There is much to be said in reference to the faulty descriptions which make up the substance of many conveyances. As an illustration of the way some of these are brought about,—a client comes to a lawyer to make out conveyance of property. It is not infrequent that one or both are ignorant of distances and sometimes of directions. The money part of the transaction is about concluded, the lawyer's fee of one to three dollars agreed to, so the latter draws up the paper,—after obtaining the general information close at hand, and the same is then a legal document ready for the public files.

This outlined, the process is simple and expeditious, and if the grantee is satisfied with more or less land and with a general indefiniteness of boundaries, the aforesaid practice would be sufficient as concerning the grantee. However, the time soon comes in our cities when by reason of a prospective sale or increase in values a city surveyor's services are sought to define exact boundaries. It is here that the above-mentioned descriptions are a guide of little value. Alike may be the descriptions of abutting lands. Each must be examined and given its due weight in coming to a decision. Luckily for the practitioner if some natural objects of long standing appear which aid his judgment to obtain just results.

The remedy for all this indefiniteness and consequent difficulty of setting off city lands in the afore-mentioned cases is obvious, as each member of this Society well knows: viz., there should be an agreement by all parties interested upon certain boundaries, such in view of all evidence obtainable. It is often best in such cases to draw up an agreement to be signed by each person interested or owning abutting property, such agreement to be recorded with the town clerk and to appear on the local town records.

In some cases quit claim deeds each side of an agreed boundary line are exchanged and such made public record. After exact boundaries are agreed upon, a survey with transit and steel tape should be made, survey plotted, when any discrepancy will appear, and thereafter a new and proper description of the tract based on exact angles and distances be written, permanent landmarks, as mere stones, being set if practicable at the principal points.

Every purchaser of property should insist upon and make the foregoing action a necessary condition before his acceptance. He would thus be the gainer even if he shared the expense. Property thus defined would make easier that of abutting lands, all together resulting in a public benefit.

MR. PUNDERFORD: I don't care to have you think I am trying to push this matter of importance through too rapidly, but this bill which they will probably present a month or two before it is called for hearing does not necessarily have to be the bill that is passed, if any bill is passed. Any member of the Society, when that is called for hearing, can appear before the committee and make suggestions as to its amendment or to the absolute killing of it, so everybody here and all members of the Society will have a shot at it before it is passed upon, if they so desire. No matter what your committee may submit they can go before the legislative committee at the public hearing and make any suggestions they see fit, and if they are desirous of having it revised the committee will undoubtedly be very glad to consider the suggestions. It simply gives a chance to pass it without waiting two years.

MR. BUNCE: I am rather disposed, Mr. President, to favor your suggestion in this matter. I think it is a matter that ought to have considerable thought and care put upon it before it is even proposed. I think you will find very likely that there may be strenuous objections to the matter. In fact, I think pushing this thing through in this way is a little bit on the style of our friend at the head of the United States government. He is trying to reform the world in a minute. The reforms are first-rate, a great many of them, but he is not taking time enough to do it and the result is he is meeting opposition which he would not if he went a little slower; and I think we ought to go a little slower in this matter. It would be better for us to have this matter thoroughly considered in the Society, because the members of the Society are widely scattered over the state, and they certainly would not be largely represented, I am sure, at a hearing before the legislature to make suggestions or to listen to discussions or anything of the kind. But if the matter was brought before the Society at some of its meetings and an opportunity given to discuss it, it seems to me we should take a more intelligent action that would not meet with opposition from any source.

Motion amended, that a committee be appointed to consider the subject and report to the Society, instead of considering the subject and introducing a bill in the legislature.

MR. FORD: It seems to me it is a question of education rather than legislation, and the Society don't want to put itself in a position of appearing before the legislature and presenting a hastily framed bill. I think it better to let the committee consider it and refer it back to the Society and let them discuss it before it goes to the legislature.

MR. HILL: Mr. President, this matter is an exceedingly important matter; it is also an exceedingly difficult matter. All engineers who have occasion to look up deeds know the difficulties of the present methods of transferring property. That need not be touched upon. But exactly what should be done is a very difficult matter to decide. Take,

for instance, farm land. A man wants to convey a piece of land, and it is the exception rather than the rule that you will find metes and bounds. They are simply bounded on so and so. It has been handed down from father to son in that way for a long time. It would be very difficult indeed to get through a legislature of farmers anything that will necessitate a survey of the property. Then again, in land that has been transferred in that way, and if a survey is required, the question is usually to find the line before the transfer can be made. If it is required that you should have a definite survey, the distances, etc., it may take months in order to find those bounds where they are so indefinite and irregular. It is a very difficult matter, and it seems to me it would be wise to take time to consider it pretty thoroughly.

MR. TURNER: I think there is a system of recording property known as the Torrens System. I am under the impression that it has recently been adopted in New York state. I am not sure. That provides, as I understand it, for a method by which surveys and records can be made in a special way which obviates most of these difficulties. It is not attempted to make it compulsory at all, but it is open to the purchaser to require it if he wishes to. It seems to me such a law as that covers the situation pretty well, because where the value of the property is high, as in the cities, it is a small matter to have it carefully surveyed and properly described; and with the farm lands it is not necessary perhaps at present and it can be done whenever the value becomes such as to make it advisable. I think if our committee should examine the Torrens system and report favorably on the adoption by our state of some such law as that it might cover the situation.

MR. BROWN: This system just mentioned, I think, is in vogue in Massachusetts, but I might say that the majority of lawyers do not favor it; it is not used to any great extent. I think they admit that it is a good thing. The engineers admit that it is a good thing, but it would eventually, if everybody availed themselves of it, probably result in a loss to engineering as a whole.

MR. BUNCE: Don't be afraid, it will take years to catch up.

MR. BROWN: My desire is to see the thing pushed along, and for that reason I seconded the motion. It certainly seems too bad to waste two years. Not that I feel like hurrying the matter or putting through legislation that would be hastily drawn and not meet the needs. It does seem, though, the way the matter is presented, that there would be time to frame a suitable bill.

MR. BURT: It seems to me that it is a most important subject and that it ought to have a good deal of deliberation and care in preparation, in order to be sure of the best results. I should not be in favor of hasty action in the matter, but I do think that it ought to be initiated and shoved along to some final result.

After some further discussion it was voted that a committee of three be appointed by the Chair to report at a future meeting of the Society on the question of land surveys and deeds.

THE PRESIDENT: Such interest has been manifested in this subject, that I hope as we are gathered here to-day, we may have expressions of

opinion on it; the remarks could be general in character and would serve as a guide to the committee in their future deliberations. I would suggest, merely to bring the point before the Society, the law be amended so that in small towns the town clerk would be compelled to refuse to record a deed unless there was a definite description of the property that was being conveyed. In other words, there must be some description that identifies that property from surrounding property. It might be that in cities, before deeds are recorded they shall have the O. K. from the city engineer that the measurements are correct. I am not certain, but I believe that the city of Philadelphia has some system of public surveys which works very well. The city is divided up into districts and there are certain maps of the district which are very accurate. I am sorry I haven't looked the question up so as to give better information about it, but they have made a long step forward in the matter of surveys. Has anyone a suggestion to make that would give this committee something to work upon?

MR. CHANDLER: It would be unfair perhaps to the committee to be appointed to suggest any difficulties, and unnecessary. They will find plenty of them. The right of each of us to convey his land to someone else without going through certain, perhaps burdensome, operations is one that will not be given up very easily, and it will be very difficult to deprive us of that right. As I understand it, the Torrens land system is one in which after a description is made there is published a notice for a certain length of time, so that if anyone has any desire to claim that the bounds as given are not correct they can remonstrate against the description, and it doesn't become effective until such notice has been given and either no remonstrance has been made or the remonstrance has been in some way overruled. The greater part of all the difficulties we labor under is in relation to things that have been done already. What we do now will not alter what has been done and it will be a long time before what is done cuts much figure in the whole of the conveyances that the surveyor has to contend with. But I am perfectly willing that some committee should devise some way of getting over all these things. If the surveyor has difficulty now in finding the line and don't know where it is, how is he going to describe it so that somebody else will know where it is?

The tellers presented the following report of the canvass of the letter ballot for officers for 1909:

	Whole number cast.	Necessary for choice.	Received.
<i>For President</i>	123	62	
*Frederick J. Easterbrook			122
Edward Gagel			1
<i>For First Vice President</i>	116	59	
*Shepard B. Palmer			62
A. William Sperry			53
Sheldon E. Minor			1

*Elected.

	Whole number cast.	Necessary for choice.	Received.
<i>For Second Vice President</i>	121	61	
*Charles A. Ferry			70
Sheldon E. Minor			51
<i>For Secretary and Treasurer</i>	117	59	
*J. Frederick Jackson			117
<i>For Directors</i>	230		
*Henry J. Kellogg			85
*Edward W. Bush			78
Charles F. Chase			66
D. S. Brinsmade			1

The President declared the men chosen elected for the ensuing year and called upon Mr. Easterbrook, who responded as follows:

MR. EASTERBROOK: Mr. President and Gentlemen of the Society. I thank you very much for the honor of electing me president. In recalling the names of the past presidents of the Society, I find that various branches of engineering have been represented, but by your choice this year will be the first year that an engineer from a railroad branch has been elected. I hope you will have no cause for regret, and I certainly ask your most hearty coöperation and support in endeavoring to attend to the affairs of the Society as successfully the coming year as they have been in the past.

MR. FARNHAM: There is a matter I would like to bring up at this time for consideration, in reference to the bill recently introduced before Congress regarding the building of a large testing machine capable of testing full-size compression members. This matter will be voted on before very long and it seemed to some of us that it would be a very good plan to have this Society express to our representatives in Washington our opinion regarding this matter. I am presenting this at the suggestion of Professor Tracy of the Scientific School, who has drawn up a brief resolution which with your permission I will read:

"Moved: That a committee of three be appointed to draw up a resolution requesting the Connecticut Senators and Representatives in Congress to urge the passage of the bill now pending for the construction of a machine capable of testing full-size compression members; such resolution to be offered to the Connecticut Society of Civil Engineers for consideration at the meeting on Wednesday, February 10." Signed by J. C. Tracy.

Resolution adopted.

MR. BUNCE: If the Society will give me fair credit for my innate modesty, I would like to suggest, as a little recognition of the fact that this is the twenty-fifth anniversary of this Society, that in the next publication of the minutes a list of the original members of the Society

* Elected.

should be printed. I do this, not because my name will appear among them, but it has been suggested by another original member that something of this kind might be of interest to the members of this Society. As I recall it, I think we have had rather a remarkable history in one respect. I believe that only two of the original members of this Society have passed away: Mr. Hull, who was really the originator and its first president; and Mr. Floyd Weld, formerly city engineer of Waterbury. I think outside of those two the original members of the Society are still living and enjoying good health.

MR. KELLOGG: I second the motion. I am another of the charter members, and I have just as much modesty as Mr. Bunce has.

Motion carried.

MR. KELLOGG: Mr. Jackson's suggestion has not met with any response in the matter of the pin, and I can say this: that while I was president the matter was brought up and a committee appointed and there was a little sketch made by one of the members. I would move that, in response to the requests of those members, a committee be appointed by the President (let him suit his own taste as to number, one man or more) just to look into this matter and bring it up at another meeting. We might as well keep the thing stirred up and sometime we may have a pin.

Motion carried.

Upon inquiry as to whether there was a complete file of the reports of the Society the Secretary stated that there was but one that he knew of, the one in the possession of the Society.

Mr. Morris being unable to be present, Mr. Payne read the paper on "The Interesting Reinforced Concrete Work in the State Arsenal and Armory."

Mr. Payne's paper is printed on pages 103-110.

MR. KELLOGG: I move a vote of thanks to Mr. Payne for the very interesting article he has given us in the description of the armory here in Hartford.

Motion seconded and carried.

THE PRESIDENT: Mr. McGarvie Cline was to deliver this talk but there is very important legislation being considered at Washington at this time in regard to the Forestry Service and he was unavoidably detained; however, we will have the pleasure of listening to Mr. Betts, who is perfectly familiar with this work and a member of the Forestry Service, and also associated with Mr. Cline in his work in Washington.

I have the pleasure of introducing Mr. Betts.

Mr. Betts' paper is printed on pages 26-40.

MR. FORD: I feel confident that every person in this room this afternoon has been personally interested in Mr. Betts' presentation of this live and interesting subject, and as a slight expression of our appreciation I move that a vote of thanks be extended to Mr. Betts personally, and also to the Forestry Bureau of the United States Government for sending him here to-day to address us.

Motion carried.

Adjourned to to-morrow morning, at nine o'clock.

MORNING SESSION—FEBRUARY 10, 1909.

The President announced the following committees:

Committee on Pin—Mr. Norman Spencer, Hartford, chairman, Clinton L. Cole, Hartford, and Mr. William Blair, of New Haven.

Committee for Consideration of the Better Property Description of Land in Deeds—Mr. Charles H. Ferry, New Haven, chairman, Mr. A. L. Washburn, Hartford, and Mr. A. J. Patton, of Waterbury.

On framing a resolution to present to our representatives in Congress asking for appropriation for big testing machine—Professor Tracy, New Haven, chairman, Mr. Chas. S. Farnham, New Haven, and Mr. Charles F. Chase, New Britain.

Mr. Henry J. Kellogg, of New Haven, read his paper on the "Reinforced Concrete Sewer at New Haven."

Mr. Kellogg's paper is printed on pages 55-68.

MR. KELLOGG: I want to state before I read this paper that it will not include a great many points of interest, and a description needs the illustrations that will appear in the book.

Mr. Roscoe N. Clark, Assistant City Engineer of Hartford, then read his paper, "Tunnel and Concrete Sewers at Hartford."

Mr. Clark's paper is printed on pages 77-91.

Mr. Bush then read his paper on "Engineer in Court."

Mr. Bush's paper is printed on pages 1-12.

THE PRESIDENT: I would like to say before I start that I have endeavored to get some member of the Society to write on this subject. It is a question I got interested in and have been studying up some myself, and I thought there was need of a paper on it. Those that I thought best qualified to write the paper I couldn't get, and having the matter somewhat arranged in my mind I decided to do it myself, though I feel that I am not as well qualified by experience as some other members of the Society.

THE PRESIDENT: Any further discussion? If not, I will call on Mr. Herbert C. Keith of New York City to present his paper on "Some Observations on the Life of Steel Bridges."

MR. KEITH: Mr. President and Members of the Connecticut Society of Civil Engineer,—I would remind you, Mr. President, that when you asked me for the title of my paper you started to write in the word "steel" and I requested you to cut that out because I wanted a broader field for talk. As it got into our programme, I am going to ask for permission to modify the title still further: "Stray Thoughts on Bridge Design and Maintenance." I think at the time I told our president the subject I had not prepared the paper, and in preparing it I have learned that this title will cover a little better what I wanted to cover in the paper.

Mr. Keith's paper is printed on pages 115-135.

Mr. Poley being absent Mr. Easterbrook read his paper on "Reinforced Concrete Round House"; the paper is printed on pages 93-102.

MR. KELLOGG: Before discussion on this paper I would like, as Mr. Poley is not a member of this Society and has very kindly contributed this paper, to move a vote of thanks to him for his kindness.

Mr. Jackson then read his paper on "Cost of Sewer Work."

Paper printed on pages 41-54.

MR. JACKSON: I would say here that most of the work is tabular and would be very dry reading. I will simply give an outline of it and it will appear in the publication for those who wish to consult it.

Mr. Taylor's paper, "An Efficient Indexing System," was then read by title; paper printed on pages 70-76.

A vote of thanks was extended to Mr. Taylor.

A vote of thanks was extended to the Hartford members and the committee on arrangement for their hospitality in entertaining the visiting members throughout the session.

Meeting adjourned.

CONSTITUTION.

ARTICLE I.

NAME AND OBJECT.

SECTION 1.—The name of this Society shall be the CONNECTICUT SOCIETY OF CIVIL ENGINEERS.

OBJECT.

SEC. 2.—The object of this Society shall be the professional improvement of its members; the encouragement of social intercourse among men of practical science, and the advancement of engineering in its several branches, to wit: Civil, hydraulic, naval, sanitary, mechanical, electrical, architectural, mining, geological, metallurgical, and chemical; the reading and discussion of papers, or to hear lectures on any of the above topics relating to engineering science, and the transaction of all business properly belonging to said Society.

ARTICLE II.

MEMBERSHIP.

SECTION 1.—The membership of this Society shall consist of Members, Honorary Members and Associate Members.

MEMBERS.

SEC. 2.—Members must be at least twenty-one years of age and have had two years' actual experience in some branch of engineering or surveying, or shall have been graduated from an engineering course in a college or university of recognized standing, and they only shall be entitled to vote or transact business for the Society.

HONORARY MEMBERS.

SEC. 3.—Honorary Members may be as many as the Society shall elect. They shall have no vote, nor shall they be eligible to hold office. They shall have the right to attend all public meetings and to enjoy such other privileges as the Society may see fit to grant, excepting, however, such Honorary Members as may be elected from *active membership*, when they shall retain their right to vote and to hold office.

ASSOCIATE MEMBERS.

SEC. 4.—Any person desiring to become associated with this Society, who is not eligible to active membership, may make application, and if said application receives a favorable report from the Board of Direction, it shall be acted upon by the Society at the next regular meeting, and if said candidate shall receive a majority of the votes cast he shall be declared elected as an Associate Member. Associate Members shall have no vote, nor shall they be eligible for any office.

ARTICLE III.

OFFICERS AND THEIR DUTIES.

OFFICERS.

SECTION 1.—The officers of this Society shall be, a President, two Vice Presidents, a Secretary and Treasurer, an Assistant Secretary, and four Directors.

ELECTION OF OFFICERS.

SEC. 2.—The officers, excepting the Assistant Secretary, shall be elected at the annual meeting, and shall hold their respective offices until the final adjournment of the meeting in which others are elected and qualified in their places.

PRESIDENT.

SEC. 3.—The President shall preside at all meetings when present. He shall be chairman of the Board of Direction, and of all standing committees, and shall appoint all special committees, unless otherwise ordered by a vote of the Society.

VICE PRESIDENTS.

SEC. 4.—In the absence or inability of the President to act, the Senior Vice President present shall perform his duties.

SECRETARY.

SEC. 5.—The Secretary shall attend all meetings of the Society, and the Board of Direction, and shall keep the minutes thereof. He shall conduct the general correspondence of the Society, receive communications addressed thereto, and present the same to the proper committees, officers, or meetings. He shall issue notices of all meetings, inform committees of their appointment, and officers and new members of their election. He shall notify all committees of coming meetings and prepare the matters for presentation. He shall keep a complete list of all members, with their addresses and dates of election. He shall publish the annual report. He shall perform such other duties pertaining to his office as may be imposed upon him by the Society or by the Board of Direction, and shall receive a salary to be fixed by the Society.

TREASURER.

SEC. 6.—The Treasurer shall keep the accounts, collect all the funds of the Society and shall deposit the same to the credit of the Society in such depository as may be designated by the Board of Direction. He shall pay all bills, when approved by the President or a majority of the Board of Direction. He shall keep book accounts of his receipts and expenditures, which shall at all times be open to the inspection of the Board. He shall make a duly audited itemized report to the annual meeting. He shall give bonds for the faithful performance of his

duties, in such amounts and with such sureties as the Board of Direction may require, and he shall receive such remuneration as the Society may vote to him from time to time. The Board of Direction shall audit the Treasurer's accounts and books annually.

ASSISTANT SECRETARY.

SEC. 7.—The Assistant Secretary shall be appointed annually by the President, and his duties shall be such as would pertain to the office of executive secretary.

BOARD OF DIRECTION.

SEC. 8.—This Board shall consist of the President, the two Vice Presidents, and the four Directors. It shall have supervision and care of all the affairs and property of the Society, and shall conduct the same in accordance with the Constitution and By-Laws. The President or one of the Vice Presidents shall preside at all meetings of the Board, in the order of seniority. In the absence of all these officers, a chairman *pro tem.* may be appointed for the meeting. The first year after this section is adopted, four members shall be chosen at the annual meeting, two shall be chosen for a term of one year and two to serve two years. At all subsequent annual meetings two members shall be chosen to serve two years. Four members shall constitute a quorum to transact business.

ARTICLE IV.

ELECTIONS.

OFFICERS, WHEN ELECTED.

SECTION 1.—At each annual meeting the Society shall elect by ballot, a President, two Vice Presidents, and a Secretary and Treasurer, to serve one year; also two Directors to serve two years.

NOMINATIONS, HOW MADE.

SEC. 2.—A nominating blank, containing a list of officers to be voted for, shall be sent by the Secretary to each member, at least sixty (60) days before the day of the annual meeting. The nominations for officers shall be returned to the Secretary in an envelope endorsed with the member's signature, within twenty-one (21) days from the date upon which the blanks were mailed to members, and shall be delivered by him, unopened, to the Board of Direction at a meeting to be held by them to canvass such nominations.

A member nominated for an office by as many as ten (10) other members may become a candidate for that office. If a member be nominated for more than one office, he shall be considered as having been nominated for that office for which he received the most nominating ballots.

If no member receives ten (10) nominating ballots for an office, or if for any reason there should be no candidate for an office, the Board of Direction shall nominate at least two candidates for that office.

All nominees for office shall be notified at once by the Secretary of their nomination and, unless the Secretary receives a prompt declination, it shall be assumed that they have accepted such nomination.

ELECTIONS, HOW CONDUCTED.

SEC. 3.—At least twenty-one (21) days before the annual meeting the Secretary shall send each member a ballot, containing the names (arranged alphabetically) of the candidates for each office. This shall be accompanied by an envelope addressed to the Secretary, with a blank space on the back for the signature of the member voting, also a blank envelope carrying no mark for recognition.

Each member shall signify his choice of candidates on the ballot and return it to the Secretary in two sealed envelopes; the inner one to be left entirely blank, and the outer one endorsed with signature of sender.

Ballots may be sent by mail to the Secretary or handed to him directly. The Secretary shall deliver the ballots, unopened, to the tellers appointed by the presiding officer.

The polls will close at eleven o'clock in the morning of the day of the regular annual business meeting of the Society.

MEMBERS IN ARREARS CANNOT VOTE.

SEC. 4.—It shall be the duty of the Treasurer to furnish the tellers with an alphabetical list of members in arrears for dues for two years or more, and no vote from a member so in arrears shall be counted. Ballots received from such members shall be returned to them unopened with a statement of the reason for such action.

PLURALITY ELECTS.

SEC. 5.—The candidate for each office receiving a plurality of the votes shall be declared elected. In case of a tie vote, the meeting shall proceed to vote by ballot for the candidates who are tied.

NOTIFICATION.

SEC. 6.—The Secretary shall officially notify in writing each officer of his election.

Officers so elected shall qualify and assume their duties immediately after the adjournment of the meeting at which they are elected, and shall hold office until their successors are duly elected and qualified.

VACANCIES.

SEC. 7.—Vacancies occurring for any cause in the list of officers shall be filled by the Board of Direction.

ELECTION OF MEMBERS.

SEC. 8.—Each application shall be announced on the notices for the next meeting after it is received, shall then be considered by the Board of Direction, and, if approved, shall be presented to the Society for

ballot at a regular meeting. If a candidate receives a majority of the ballots, he shall be declared elected. In case of rejection, no minute shall be published, but the Secretary shall notify the applicant by letter.

APPLICATION FOR MEMBERSHIP.

SEC. 9.—All applications for membership or for transfer from one grade of membership to another, shall be made on a regular form, to be secured from the Secretary, and to be endorsed by three Members. This form shall contain, immediately over the signature of the applicant, a clause in which the applicant shall agree that if elected he will be governed in all Society matters by the Constitution and By-Laws, and will forward the interest of the Society at all times.

ARTICLE V.

MEETINGS.

ANNUAL MEETING.

SECTION 1.—There shall be a *regular annual meeting* held on the second Tuesday of February each year, at such place as may be selected by the Board of Direction, of which due notice shall be given by the Secretary.

MEETINGS, HOW CALLED.

SEC. 2.—Special meetings may be called by the President and, when so called, notice of the meeting specifying the business thereof shall be mailed by the Secretary to the postoffice address of each member at least ten days before such meeting shall be held. Special meetings shall be called by the President on written application of any ten (10) members.

QUORUM.

SEC. 3.—Ten per cent. of the membership shall constitute a quorum for the transaction of ordinary business, except for the election of officers or for voting on amendments to the Constitution or By-Laws, which shall require fifteen per cent.

ARTICLE VI.

DUES.

SECTION 1.—The annual dues of Members and Associate Members shall be three (\$3.00) dollars per year, payable in advance at the annual meeting.

Members elected at any time of the year shall pay full dues for that year.

SEC. 2.—Honorary Members shall pay no annual dues.

SEC. 3.—The Board of Direction shall have power to remit dues when, in their opinion, it is for the best interest of the Society.

ARTICLE VII.

DEPRIVATION OF MEMBERSHIP.

SECTION 1.—Any member whose dues shall remain unpaid for two (2) years shall be notified by the Treasurer, by sending by registered mail a bill for dues in arrears, on the face of which bill shall be printed the sections of the Constitution covering such cases. If the dues are not paid within thirty (30) days after such notification, the matter shall be presented to the Board of Direction, who shall have power to drop such member from the roll.

RESIGNATIONS.

SEC. 2.—Resignations must be submitted in writing to the Secretary, and may be accepted by the Board of Direction when all indebtedness to the Society has been discharged.

SEC. 3.—All charges against any member shall be investigated by the Board of Direction before being submitted to the Society.

Any member may be expelled for conduct which may be deemed prejudicial to the Society, by a two-thirds vote of the Members present at a business meeting; provided, that not less than fifteen (15) vote for expulsion, and that such member shall have had one month's notice of the charges preferred against him and of the time appointed for their consideration. All charges must fully set forth the offense or offenses alleged, and must be signed by the members preferring them. An attested copy must be furnished the accused, who shall be entitled to be present and to be heard in defense, in person or by attorney, at all meetings at which the charges are investigated, except during the time when a final vote is being taken.

ARTICLE VIII.

AMENDMENTS TO THE CONSTITUTION.

SECTION 1.—Proposed amendments to this Constitution must be presented in writing at a regular business meeting of the Society, and signed by at least three Members.

Amendments so presented shall be read at the meeting and a copy filed with the Secretary at the same time. At the meeting when presented the proposed amendments may be discussed and amended, but cannot be adopted.

SEC. 2.—At any regular business meeting the amendments previously proposed, according to Section 1, may be voted upon by letter ballot. These ballots shall be sent out with the call for the meeting and shall have the proposed amendment, together with the section of the present Constitution covering the point in question, printed upon the ballot. With the ballot shall also be sent an envelope directed to the Secretary and marked "Ballot on Amendment." The Secretary shall keep these letters unopened and present to the presiding officer all replies received

up to the hour of closing the polls. Tellers shall be appointed by the presiding officer, who shall open and count all ballots. The result shall be announced at the meeting by the presiding officer. Two-thirds of the ballots cast will be necessary for the adoption of an amendment.

SEC. 3.—The Board of Direction is authorized to number the Articles and Sections of the Constitution and By-Laws to correspond with any changes that may be made.

BY-LAWS.

MEETINGS.

1. In addition to the regular annual meeting, as provided by the Constitution, the Society shall hold at least one other general meeting, and may hold such other meetings to listen to lectures or addresses, or to visit engineering works of interest, or of a purely social nature, as the Board of Direction may decide to call.

GENERAL ORDER OF BUSINESS AT ANNUAL MEETING.

2. The following general order of business shall be observed at annual meetings:

1. Presentation of, and action upon, minutes of last meeting.
2. Report of Board of Direction.
3. Report of Secretary.
4. Report of Treasurer.
5. Report of any Special Committees.
6. Election of new members.
7. Election of officers.
8. Address of President.
9. Miscellaneous business.
10. Papers, lectures, or addresses.
11. Adjournment.

BUSINESS MEETINGS—ORDER.

3. The following general order shall be observed at Business Meetings:

1. Presentation of, and action upon, minutes of last meeting.
2. Miscellaneous announcements.
3. Stated business.
4. Adjournment.

4. Contributing Members under the old Constitution shall become Associate Members upon the adoption of the Revised Constitution.

5. Actual personal transportation expenses incurred by the Secretary in attending meetings shall be paid from the Society treasury, upon approval of the President or two members of the Board of Direction.

6. In the election of Honorary Members, a unanimous vote is necessary to elect.

7. The Society may at any time, duly named for the purpose, enact By-Laws for the future guidance, consonant with the Constitution. These By-Laws may be amended or repealed at any meeting, in the call for which meeting a copy of the proposed amendment or addition shall have been printed and sent to each member with the said notice.

PARLIAMENTARY RULES.

8. In all questions arising at any meeting, involving parliamentary rules, not provided for in these By-Laws, Roberts' Rules of Order shall be the governing authority.

VISITORS.

9. Visitors may be admitted to meetings under such rules as the meeting may prescribe.

10. All forms, such as blanks for application for membership, ballots for officers, ballots on amendments to Constitution or By-Laws, and other necessary blanks for the conduct of the business of the Society, shall be prepared by the Secretary and approved by the Board of Direction.

CHARTER MEMBERS OF THE SOCIETY.

HONORARY

PROF. JOHN E. CLARK.....	April, 1884
GEORGE H. FROST.....	April, 1884

ACTIVE

E. P. AUGUR.....	April, 1884
H. W. AYRES.....	Jan. 13, 1885
G. H. BISHOP.....	Jan. 13, 1885
D. S. BRINSMADE.....	April, 1884
C. H. BUNCE.....	April, 1884
L. W. BURT.....	Jan. 13, 1885
C. E. CHANDLER.....	April, 1884
R. S. HULBERT.....	April, 1884
C. M. JARVIS.....	April, 1884
H. J. KELLOGG.....	April, 1884
F. W. LAFORGE.....	Jan. 13, 1885
J. M. MCKENZIE.....	April, 1884
W. B. PALMER.....	Jan. 13, 1885
S. C. PIERSON.....	Jan. 13, 1885
A. W. RICE.....	April, 1884
WILLIAM G. SMITH.....	April, 1884
NELSON J. WELTON.....	April, 1884
J. K. WILKES.....	April, 1884

List of Members.

With Addresses and Dates of Election.

Members are particularly requested to inform the Secretary at once of any change in address.

HONORARY MEMBERS.

CHITTENDEN, PROF. RUSSELL H.	April 20, 1901
Dean of Sheffield Scientific School of Yale University, New Haven, Conn.	
CLARK, JOHN E.	April, 1884
Prof. Mathematics, Emeritus, at Sheffield Scientific School, Yale University, South Terrace, Longmeadow, Mass.	
FITZGERALD, DESMOND	Jan. 8, 1901
Consulting Engineer, Brookline, Mass.	
FROST, GEORGE H.	April, 1884
President Engineering News Publishing Co., New York.	
FULLER, WILLIAM B.	Feb. 12, 1908
Consulting Engineer, 170 Broadway, New York.	
HADLEY, DR. ARTHUR T.	April 20, 1901
President Yale University, New Haven, Conn.	
HAUPT, LEWIS	Feb. 12, 1907
Consulting Engineer, Philadelphia, Pa.	
HAYNES, EDWARD C.	Jan. 14, 1890
Rodman, N. Y.	
PETTEE, WILLIAM E.	Jan. 10, 1899
Civil Engineer, Salisbury, Conn.	
SEYMOUR, WILLIAM O.	Feb. 9, 1904
Railroad Commissioner, Ridgefield, Conn.	
SKINNER, FRANK W.	Jan. 9, 1900
Editorial Staff of the Engineering Record, New York.	
SCOFIELD, HORACE G.	Feb. 14, 1906
Civil Engineer, Bridgeport, Conn.	

MEMBERS.

ALDERSON, ALGERNON B.	Jan. 10, 1899
Town Engineer, West Hartford, Conn.	
ALLEN, GEORGE B.	Aug. 12, 1908
Department of Parks, New Haven, Conn.	
AMRHYN, GUSTAVE X., Associate Member	Feb. 9, 1904
Department of Parks, New Haven, Conn.	
AUGUR, EDWIN P.	April, 1884
Civil Engineer and Surveyor, and City Surveyor, Middletown, Conn.	

AYRES, HENRY W.	Jan. 13, 1885
Hydraulic Engineer, Hartford, Conn.	
AZHDERIAN, REUBEN B.	Feb. 12, 1907
Civil Engineer, Bridgeport Hydraulic Co., Bridgeport, Conn.	
BACON, ARTHUR W.	Feb. 9, 1904
Civil Engineer, New Britain, Conn.	
BANTA, D. SCHUYLER	Aug. 23, 1905
Civil Engineer, Hartford, Conn.	
BARKER, WILLIAM H.	Aug. 10, 1904
Jenkins & Barker, Hartford, Conn.	
BARNEY, SAMUEL E.	Jan. 9, 1900
Prof. Civil Engineering Sheffield Scientific School, Yale University, New Haven, Conn.	
BEACH, CHARLES EDWARD	Jan. 10, 1893
Civil Engineer, West Hartford, Conn.	
BELDEN, CLIFFORD H.	March 30, 1900
Civil Engineer, New London, Conn.	
BELDEN, EDGAR T.	Jan. 8, 1901
Box 931, Pittsfield, Mass.	
BENNETT, CHAS. J.	Aug. 14, 1906
Engineering Department, N. Y., N. H. & H. R. R. Co., Hartford, Conn.	
BENNETT, RAYMOND F.	March 30, 1900
W. F. Bennett & Son, Contractors, Portland, Maine.	
BIGELOW, HORATIO	Aug. 14, 1907
Civil Engineer, Norwich, Conn.	
BISHOP, GEORGE H.	Jan. 13, 1885
Hydraulic Engineer, Middletown, Conn.	
BLACK, WILLIS J.	Feb. 13, 1906
Civil Engineer, N. Y., N. H. & H. R. R., New Haven, Conn.	
BLAIR, CLARENCE M.	Aug. 10, 1904
Civil Engineer, New Haven, Conn.	
BLAKESLEE, CLARENCE	Jan. 9, 1900
Civil Engineer and Contractor, New Haven, Conn.	
BLATCHLEY, WILLIAM J.	Aug. 10, 1904
Civil Engineer, New Haven, Conn.	
BLEIM, DANIEL WILLIAM	Feb. 12, 1907
Manager American Bridge Co., East Berlin, Conn.	
BODFISH, HENRY L.	Feb. 13, 1906
Civil Engineer, N. Y., N. H. & H. R. R. Co., Waterbury, Conn.	
BRADLEY, DANIEL E.	Jan. 9, 1894
President Berlin Construction Co., Berlin, Conn.	
BRAINARD, ALBERT S.	Aug. 12, 1908
Civil Engineer, East Hartford, Conn.	
BRETT, THOMAS C.	Aug. 10, 1904
Secretary Yale Safe & Iron Works, New Haven, Conn.	
BREWER, WILLARD SEYMOUR	Feb. 12, 1907
City Engineer's Office, Hartford, Conn.	
BRINSMADE, DANIEL E.	April 20, 1901
Secretary and Assistant Engineer Ousatonic Water Co., Shelton, Conn.	
BRINSMADE, D. S.	April, 1884
Engineer Housatonic Water Power Co., Derby, Conn.	
BRISTOL, WARREN P.	Aug. 12, 1908
Associate Member, Hartford, Conn.	

LIST OF MEMBERS.

165

BROWN, CHARLES B.	Aug. 14, 1907
Prof. of Railroad Engineering, University of Maine, Orono, Maine.	
BROWN, CHARLES O.	Jan. 11, 1898
City Engineer, Danbury, Conn.	
BROWN, EDMUND	Jan. 10, 1899
Superintendent and Engineer of Norfolk Water Co., Norfolk, Conn.	
BROWN, WALTER A.	Feb. 13, 1906
Civil Engineer, Springfield, Mass.	
BROWN, WALTER A.	Feb. 13, 1906
Engineering Dep't., N. Y., N. H. & H. R. R., Waterbury, Conn.	
BUCK, HENRY R.	Jan. 10, 1899
Civil Engineer, Hartford, Conn.	
BUNCE, CHARLES H.	April, 1884
Civil Engineer, Hartford, Conn.	
BURGHARDT, WALLACE	Feb. 13, 1906
Town Engineer, North Canaan, Conn.	
BURT, LUTHER HAROLD	Aug. 14, 1900
Assistant Engineer, Bronx Valley Sewer Commission, White Plains, N. Y.	
BURT, LUTHER W.	Jan. 13, 1885
Civil Engineer and Surveyor, Hartford, Conn.	
BUSCHOR, EMIL CHARLES	Jan. 10, 1899
Civil Engineer and Surveyor, Arlington, N. J.	
BUSH, EDWARD W.	Jan. 10, 1899
Assistant Engineer, Conn. River Bridge and Highway District, Hartford, Conn.	
BUSHNELL, W. G., Associate Member	Feb. 14, 1905
Electrical Engineer, New Haven, Conn.	
CADWELL, WILLIAM H.	May 31, 1893
Civil Engineer, New Britain, Conn.	
CAHN, ALEXANDER	Jan. 9, 1900
Civil Engineer, New Haven, Conn.	
CAIRNS, ROBERT A.	Aug. 29, 1890
Sanitary and Hydraulic Engineer and City Engineer, Waterbury, Conn.	
CAMPBELL, CARROL A.	Feb. 9, 1909
Civil Engineer, West Hartford, Conn.	
CANFIELD, ANDREW G.	Feb. 9, 1909
Civil Engineer, Bridgeport, Conn.	
CARLISLE, HARRY E.	Jan. 9, 1900
Conduit Engineer, S. N. E. Telephone Co., New Haven, Conn.	
CARTER, RALPH B.	Jan. 14, 1890
Civil Engineer, 26 Cortlandt St., New York.	
CAUM, FRANK	Aug. 14, 1900
General Manager Scranton Railway Co., Scranton, Pa.	
CHANDLER, CHARLES E.	April, 1884
Civil Engineer, Norwich, Conn.	
CHAPMAN, FREDERICK S.	Feb. 10, 1903
Civil Engineer, Philippine Islands.	
CHASE, CHARLES F.	March 30, 1900
Engineer Berlin Construction Co., New Britain, Conn.	
CHENEY, RICHARD OTIS, JR.	Jan. 9, 1900
Civil Engineer, South Manchester, Conn.	
CHILD, JONATHAN H.	Feb. 11, 1908
Superintendent Water Works, Wallingford, Conn.	

CLARK, HERBERT G.	July 18, 1899
Engineer of Keney Park, Hartford, Conn.	
CLARK, ROSCOE N.	July 18, 1899
Assistant City Engineer, Hartford, Conn.	
CLARK, VINCENT B.	Feb. 9, 1904
City Engineer, Ansonia, Conn.	
CLARK, WILLIAM S.	July 14, 1890
Civil Engineer, Meriden, Conn.	
COE, ROBERT J.	Aug. 12, 1908
Civil Engineer, Waterbury, Conn.	
COE, THEODORE I.	Jan. 9, 1900
Architect, 100 William St., New York.	
COGGESHALL, R. C. P.	June, 1887
Superintendent of Water Works, New Bedford, Mass.	
COLE, CLINTON L.	Feb. 9, 1904
Civil Engineer, Conn. River Bridge and Highway District, Hartford, Conn.	
COLE, REMSEN B., JR.	Feb. 9, 1909
Civil Engineer, Waterbury, Conn.	
COLLINS, HARRY C.	July 18, 1899
Berlin Construction Co., Boston, Mass.	
COMSTOCK, LEWIS B.	Aug. 10, 1904
Civil Engineer, New Rochelle, N. Y.	
CONE, JOSEPH W.	Aug. 12, 1908
Civil Engineer, Greenwich, Conn.	
CORSON, WILLIAM R. C.	Feb. 10, 1903
Electrical Engineer, Hartford, Conn.	
CRANDALL, GEORGE K.	Jan. 11, 1887
City Engineer, New London, Conn.	
CRAWFORD, CHARLES M.	July 18, 1899
Civil Engineer, New Haven, Conn.	
CRAWFORD, NORMAN McDONALD	July 18, 1899
Consulting Engineer, Cincinnati, Ohio.	
CURTIS, FAYETTE S.	Jan. 9, 1900
Vice President N. Y., N. H. & H. R. R., Boston, Mass.	
CURTISS, GREY WILLIS	Feb. 12, 1907
Civil Engineer, N. Y., N. H. & H. R. R. Co., New Haven, Conn.	
DABOLL, LOREN E.	Jan. 8, 1895
Civil Engineer, New London, Conn.	
DARROW, COURTLAND R.	Jan. 8, 1895
Civil Engineer, Waterford, Conn.	
DAVIS, ARTHUR L.	July 18, 1899
Assistant to President, American Bridge Co., 30 Church St., New York.	
DAVIS, F. IRWIN	Oct. 11, 1902
Architect, Hartford, Conn.	
DAWLEY, EDWIN P.	Aug. 14, 1906
Consulting Engineer, 532 Banigan Bldg., Providence, R. I.	
DENMAN, MATTHIAS W.	Feb. 11, 1908
Civil Engineer, Springfield, Mass.	
DEPEYSTER, FREDERICK	Sept. 3, 1891
General Manager Brainard, Schaler & Hall Quarry, Portland, Conn.	
DEYO, SOLOMON LEF.	Jan. 9, 1900
Chief Engineer New York Rapid Transit Subway Construction Co., New York City, N. Y.	

LIST OF MEMBERS.

167

DuBOIS, AUGUSTUS J.	Jan. 9, 1900
Prof. Civil Engineering Sheffield Scientific School, Yale University, New Haven, Conn.	
DUNCAN, EDGAR T.	Feb. 14, 1905
Civil Engineer, Hartford, Conn.	
DUNHAM, WILLIAM ROBERT, JR.	Feb. 12, 1907
Civil Engineer Consolidated Railway Co., New Haven, Conn.	
EASTERBROOK, FREDERICK J.	March 30, 1906
Assistant Engineer, N. Y., N. H. & H. R. R. Co., New Haven, Conn.	
EDDY, CHARLES W.	Jan. 9, 1900
Assistant Engineer, Waterbury Water Supply, Thomaston, Conn.	
ELLSWORTH, FREDERICK H.	March 30, 1900
Division Engineer, N. Y., N. H. & H. R. R. Co., New Haven, Conn.	
EVERIT, EDW. H.	Oct. 11, 1902
Engineer S. N. E. Telephone Co., New Haven, Conn.	
FARNHAM, CHARLES S.	Feb. 9, 1904
Instructor Civil Engineering Sheffield Scientific School, Yale University, New Haven, Conn.	
FERRY, CHARLES A.	Jan. 9, 1900
Civil Engineer and Surveyor, New Haven, Conn.	
FORD, FREDERICK L.	Jan. 12, 1897
City Engineer, Hartford, Conn.	
FORD, THEODORE B.	April 20, 1901
Civil Engineer, Bridgeport, Conn.	
FULTON, WILL H.	Jan. 8, 1901
City Engineer's Office, New Haven, Conn.	
GAGEL, EDWARD	Jan. 9, 1900
Chief Engineer N. Y., N. H. & H. R. R. Co., New Haven, Conn.	
GIBBS, NATHAN J.	Feb. 9, 1909
Civil Engineer, Norwich, Conn.	
GILLETTE, GEORGE W. F.	Jan. 9, 1900
Gillette Construction Co., Malley Bldg., New Haven, Conn.	
GLADDING, HENRY H.	Jan. 9, 1900
Assistant City Engineer, New Haven, Conn.	
GOSS, EDWARD O.	Nov. 29, 1890
Assistant Treasurer Scovil Mfg. Co., Waterbury, Conn.	
GRAVES, EDWIN D.	Oct. 25, 1895
Chief Engineer Conn. River Bridge and Highway District, Hartford, Conn.	
GREENWOOD, ALBERT H.	Feb. 9, 1904
With Berlin Construction Co., Berlin, Conn.	
GREGORY, J. LOUIS	Aug. 10, 1904
Civil Engineer, Larchmont, N. Y.	
HALE, PERRY T. W.	Feb. 10, 1903
Superintendent Middletown Water Works, Middletown, Conn.	
HALL, A. CLARK	Jan. 8, 1901
Hartford Water Department, West Hartford, Conn.	
HALL, CHARLES ERNEST	Feb. 12, 1907
Civil Engineer, Consolidated Railway Co., New Haven, Conn.	
HALL, WILLIAM HENRY	Feb. 12, 1907
Engineering Department, N. Y., N. H. & H. R. R., New Haven, Conn.	
HAND, GEORGE F.	Feb. 13, 1906
Civil Engineer, West Haven, Conn.	
HANS, ALEXANDER JOSEPH	Feb. 12, 1907
Civil Engineer, Locust Valley, L. I.	

HARRISON, IRVING WARREN	Feb. 12, 1907
City Engineer's Office, Waterbury, Conn.	
HARTE, CHARLES R.	Aug. 10, 1904
Civil Engineer, N. Y., N. H. & H. R. R., New Haven, Conn.	
HASTINGS, F. B., Associate Member	Feb. 10, 1903
B. D. Pierce Co., Bridgeport, Conn.	
HATCH, CHARLES	Feb. 13, 1906
Civil Engineer, N. Y., N. H. & H. R. R. Co., New Haven, Conn.	
HAWLEY, ARTHUR S.	Feb. 11, 1902
C. W. Blakeslee & Sons, New Haven, Conn.	
HENDERSON, JOHN T.	July 18, 1899
Assistant Engineer Conn. River Bridge and Highway District, Hartford, Conn.	
HICKEY, WILLIAM F., Associate Member	Feb. 9, 1909
Care of Carnegie Steel Co., Boston, Mass.	
HILL, ALBERT B.	Jan. 9, 1900
Civil and Consulting Engineer, New Haven, Conn.	
HINE, FRANK E.	April 20, 1901
Civil Engineer, Fisher's Island, N. Y.	
HOSLEY, ROBERT M.	Aug. 23, 1905
Civil Engineer, N. Y., N. H. & H. R. R. Co., New Haven, Conn.	
HOYT, SAMUEL N., JR.	Feb. 9, 1904
Civil Engineer, South Norwalk, Conn.	
HULBERT, ROBERT S., ...	April, 1884
Civil Engineer, Winsted, Conn.	
HULBERT, TIMOTHY ANDREWS	Feb. 12, 1907
Engineering Department, American Brass Co., Waterbury, Conn.	
HUNTER, FRED C.	Aug. 12, 1908
Civil Engineer, Waterbury, Conn.	
HURLBURT, HINMAN B.	Aug. 14, 1907
Civil Engineer, Canadian Pacific R. R., Montreal, Canada.	
JACKSON, J. FREDERICK	Jan. 9, 1900
Civil Engineer, New Haven, Conn.	
JAMESON, MINOR S.	Feb. 9, 1904
Assistant Engineer, N. Y., N. H. & H. R. R. Co., New Rochelle, N. Y.	
JARVIS, CHARLES M.	April, 1884
Vice President P. & F. Corbin Co., New Britain, Conn.	
JAYNES, FRANK B.	Feb. 10, 1903
Civil Engineer, Bridgeport, Conn.	
JESSUP, JOHN C., JR.	Feb. 9, 1904
Superintendent Foundation Co., Rochester, N. Y.	
JOHNSON, GEORGE R.	Aug. 14, 1906
Civil Engineer, West Haven, Conn.	
JOHNSON, WILLIAM D.	Aug. 14, 1900
Architect, Hartford, Conn.	
JOHNSON, WILLIAM E.	Nov. 29, 1890
Engineer of Hartford Water Works, West Hartford, Conn.	
JONES, WALTER A.	Feb. 10, 1903
Civil Engineer, New Haven, Conn.	
KEENEY, ERNEST A.	Feb. 14, 1905
Civil Engineer Conn. River Bridge and Highway District, Hartford, Conn.	
KEHR, HARRY T.	Aug. 10, 1904
Civil Engineer, 330 W. 4th St., New York, N. Y.	
KEITH, HERBERT C.	Jan. 9, 1900
Consulting Engineer, 1213 Morton Bldg., 116 Nassau St., New York City.	

LIST OF MEMBERS.

169

KELLOGG, HENRY J.	April, 1884
First Assistant City Engineer, New Haven, Conn.	
KELLY, CASSIUS W.	Jan. 9, 1900
City Engineer, New Haven, Conn.	
KERSHAW, WILLIAM H.	Feb. 9, 1909
Civil Engineer, Bridgeport, Conn.	
KIRBY, RICHARD S.	March 30, 1900
Instructor in Civil Engineering, Sheffield Scientific School, Yale University, New Haven, Conn.	
KOPCZYNSKI, LEON	Feb. 12, 1907
Civil Engineer, New Haven, Conn.	
LAForge, FREDERICK W.	Jan. 13, 1885
U. S. Engineer, Fort Terry, Plum Island, N. Y.	
LANE, E. LeROY	Jan. 8, 1901
Contractor, Hingham, Mass.	
LANE, JOHN S.	Jan. 8, 1901
John S. Lane & Sons, Meriden, Conn.	
LAWWETT, HENRY B., Associate Member	Aug. 14, 1907
Civil Engineer, Waterbury, Conn.	
LAW, WALTER H.	Aug. 10, 1904
Civil Engineer, Fall River, Mass.	
LAWTON, EDWIN F.	March 30, 1900
Superintendent Hartford Electric Light Co., Hartford, Conn.	
LEACH, SMITH S.	Jan. 8, 1901
Major Engineers, U. S. Government, Washington, D. C.	
LEWIS, EVERETT W.	Feb. 9, 1909
Civil Engineer, New Haven, Conn.	
LEWIS, ROBERT P.	Oct. 24, 1895
Secretary Blake & Johnson, Waterbury, Conn.	
LIBBEY, JOSEPH H.	Feb. 13, 1906
Assistant Electrical Engineer, N. Y., N. H. & H. R. R., West Newton, Mass.	
LINES, FRANK H.	Aug. 14, 1907
Civil Engineer, N. Y., N. H. & H. R. R., New Haven, Conn.	
LOCHRIDGE, ELBERT E.	Aug. 23, 1905
Civil Engineer, Springfield, Mass.	
LOUNDES, RAWLINS	Feb. 9, 1909
Assistant City Engineer, Waterbury, Conn.	
LUTHER, FLAVEL S., JR.	Feb. 9, 1904
President Trinity College, Hartford, Conn.	
LYON, C. T.	Feb. 12, 1907
Engineering Department, N. Y., N. H. & H. R. R., New Haven, Conn.	
LYNCH, ALEXANDER S.	Aug. 14, 1907
Civil Engineer, N. Y., N. H. & H. R. R., New Haven, Conn.	
MAGILL, CLAUDE	Aug. 14, 1907
Secretary Hassam Paving Co., New Haven, Conn.	
MALONEY, DENNIS J.	April 20, 1901
Superintendent of Buildings, Board of Education, New Haven, Conn.	
MALONEY, FRANK A.	Jan. 9, 1900
Assistant City Engineer, New Haven, Conn.	
MANNING, GEORGE E.	Jan. 11, 1898
Civil Engineer, Yantic, Conn.	
MARCHANT, ORSON H.	Feb. 14, 1905
Civil Engineer, New Haven, Conn.	

McCONNELL, GEORGE B.	Feb. 9, 1909
Civil Engineer, New Haven, Conn. .	
McELROY, JAMES A.	Feb. 9, 1909
Civil Engineer, Bridgeport, Conn.	
McKENZIE, J. M.	April, 1884
Civil Engineer and Surveyor, Yalesville, Conn.	
McKENZIE, THEODORE H.	April, 1888
Sanitary and Hydraulic Engineer, Southington, Conn.	
McKENZIE, THOMAS	Feb. 12, 1907
Superintendent of Water Works and Town Engineer, Westerly, R. I.	
McKNIGHT, JOHN T.	May 31, 1893
City Engineer, Rockville. Residence, Ellington, Conn.	
McLEAN, GEORGE H.	Feb. 9, 1904
Civil Engineer, New Haven, Conn.	
MERRELS, CHARLES W.	Jan. 9, 1900
City Engineer's Office, New Haven, Conn.	
MERRITT, MALCOLM	Aug. 12, 1908
Civil Engineer, Port Chester, N. Y.	
MILLER, RODNEY B.	Feb. 9, 1909
Civil Engineer, New Haven, Conn.	
MILLER, WILLIAM H.	Aug. 12, 1908
Civil Engineer, Waterbury, Conn.	
MINOR, EDWARD E.	Feb. 9, 1904
Civil Engineer, New Haven, Conn.	
MINOR, JUDSON M.	Feb. 13, 1906
Civil Engineer, 82 Church St., New Haven, Conn.	
MINOR, SHELDON E.	Sept. 25, 1886
Civil Engineer, Greenwich, Conn.	
MITCHELL, ROBERT E.	Jan. 9, 1900
Civil Engineer and Surveyor, Willimantic, Conn.	
MOORE, WM. HARLEY	Jan. 9, 1900
Engineer of Bridges, N. Y., N. H. & H. R. R., New Haven, Conn.	
MORTON, WALTER S.	Aug. 10, 1904
Morton & Burritt, Civil Engineers, New York, N. Y.	
MOSS, ERNEST B.	April 20, 1901
Civil Engineer, H. Wales Lines Co., Meriden, Conn.	
MURPHY, HAROLD T.	Feb. 9, 1904
Civil Engineer, Springfield, Mass.	
MURPHY, JOHN P.	July 18, 1899
City Engineer's Office, Hartford, Conn.	
NASH, PAUL	Jan. 9, 1900
Superintendent Public Works, Stamford, Conn.	
NICHOLS, CHARLES H.	Jan. 8, 1901
Consulting Engineer and Engineer of Shell Fish Commission, New Haven, Conn.	
NOERR, ROBERT COLLYER	Feb. 12, 1907
Civil Engineer, Berlin Construction Co., Hartford, Conn.	
O'CONNOR, DON, Associate Member	Feb. 9, 1904
D. F. Keenan, Hartford, Conn.	
OLDERSHAW, FRANCIS H.	Jan. 8, 1901
City Engineer, New Britain, Conn.	
OLDS, HERBERT V.	Feb. 9, 1909
Civil Engineer, Hartford, Conn.	

LIST OF MEMBERS.

171

OLMSTED, C. HENRY	July 18, 1899
Civil Engineer and Surveyor, East Hartford, Conn.	
OLSEN, JOHN	Feb. 12, 1907
Civil Engineer, 82 Church St., New Haven, Conn.	
ORROK, GEORGE A.	Feb. 9, 1909
Civil Engineer, Flatbush, N. Y.	
OSBORNE, FRED H.	Jan. 9, 1900
Civil Engineer Harrington Robinson Co., Boston, Mass.	
OWEN, ELIJAH H.	March 30, 1900
Care of Vorce Engineering Co., Perry-Payne Bldg., Cleveland, Ohio.	
PALMER, GEORGE E.	March 30, 1900
Assistant Engineer N. Y., N. H. & H. R. R., West Haven, Conn.	
PALMER, SHEPARD B.	Jan. 8, 1895
Civil Engineer and Surveyor, Norwich, Conn.	
PALMER, WILLIAM B.	Jan. 13, 1885
Civil Engineer and Surveyor, Bridgeport, Conn.	
PARDEE, WILLIAM S., Associate Member	Aug. 10, 1904
Wright & Pardee, New Haven, Conn.	
PARKER, GEORGE A.	July 18, 1899
Superintendent of Keney Park, Hartford, Conn.	
PARSONS, HAROLD A.	Aug. 14, 1900
Civil Engineer, Stamford, Conn.	
PATIENCE, FREDERICK G.	Feb. 9, 1909
Civil Engineer, New Britain, Conn.	
PATTON, ARTHUR J.	Sept. 12, 1889
Land Surveyor, Waterbury, Conn.	
PEARSON, ROBERT L.	Aug. 14, 1906
Civil Engineer, Saugatuck, Conn.	
PECK, ERMON M.	Jan. 8, 1895
Assistant Engineer Hartford Water Works, West Hartford, Conn.	
PECK, LEON F.	Oct. 11, 1902
Civil Engineer, Greenwich, Conn.	
PENDLETON, CLAUDIUS V.	Aug. 10, 1904
Civil Engineer, Newark, N. J.	
PENFIELD, GEORGE W.	Jan. 8, 1901
Civil Engineer, New Britain, Conn.	
PHELPS, JAMES W.	Oct. 11, 1902
Landscape Architect, Bolton, Conn.	
PIERCE, BRADFORD D., JR.	Aug. 23, 1905
Civil Engineer, Bridgeport, Conn.	
PIERCE, WILLIAM B.	Feb. 9, 1904
Civil Engineer, Stamford, Conn.	
PIERSON, STEPHEN C.	Jan. 13, 1885
Civil Engineer and Surveyor, Meriden, Conn.	
PIKE, WILLIAM K.	Feb. 9, 1904
Civil Engineer, Danielson, Conn.	
POEHLANDT, WALTER	Feb. 12, 1907
Engineering Department, N. Y., N. H. & H. R. R., New Haven, Conn.	
PRESTON, CHARLES HENRY, JR.	Feb. 12, 1907
Civil Engineer, N. Y., N. H. & H. R. R., Waterbury, Conn.	
PUNDERFORD, JOHN K.	Jan. 9, 1900
Gen. Manager Connecticut Co., New Haven, Conn.	
REYNOLDS, WM. B.	Aug. 14, 1900
Land Surveyor, Waterbury, Conn.	

RICE, ARTHUR W.	April, 1884
Treasurer Conn. Loan and Realty Co., Hartford, Conn.	
RICHARDS, WALTER H.	March 30, 1903
Engineer of Water and Sewer Department, New London, Conn.	
RIGGS, GARDINER G.	Feb. 9, 1909
Civil Engineer, Waterbury, Conn.	
RIGHTS, LEWIS D.	Aug. 10, 1904
Civil Engineer, 45 Broadway, New York City.	
ROBINSON, HALBERT G.	Jan. 11, 1898
Civil Engineer and Surveyor, Patten, Maine.	
ROBINSON, LEONI W.	Feb. 14, 1905
Architect, New Haven, Conn.	
ROBINSON, SEYMOUR N.	Feb. 9, 1904
Civil Engineer, Hartford, Conn.	
ROGERS, CHARLES EDWIN	Feb. 12, 1907
Prof. Civil Engineering, Trinity College, Hartford, Conn.	
ROLLINS, ROBERT W.	Jan. 9, 1900
General Manager Hartford Electric Light Co., Hartford, Conn.	
ROOT, CLIFFORD ANSON	Feb. 12, 1907
Civil Engineer, Hartford, Conn.	
RUFF, JOHN S.	Feb. 12, 1907
Engineering Department, N. Y., N. H. & H. R. R., New Haven, Conn.	
RYDER, ELY M. T.	Jan. 9, 1900
Civil Engineer, 171 W. 95th St., New York, N. Y.	
SAGE, GEORGE H.	Jan. 8, 1895
Vice President Berlin Construction Co., Berlin, Conn.	
SAUNDERS, RICHARD L.	Feb. 9, 1909
Assistant City Engineer, New Britain, Conn.	
SCHILLING, ALBERT H.	Aug. 14, 1906
Berlin Construction Co., New Britain, Conn.	
SELLARS, PHILIP	Feb. 9, 1904
Civil Engineer, New Haven, Conn.	
SHAUGHNESSY, JAMES F.	Feb. 11, 1902
Care of Board of Water Commission, New Hartford, Conn.	
SHAW, GEO. H.	Aug. 23, 1905
Assistant Engineer Board of Water Supply, 299 Broadway, N. Y.	
SHELDON, PAUL	Feb. 12, 1907
City Engineer's Office, Hartford, Conn.	
SIBLEY, CHARLES A.	Feb. 11, 1908
868 Elm St., New Haven, Conn.	
SLOCUM, CURLYS L.	Aug. 25, 1905
Civil Engineer, Penn. Tunnel and Terminal Railroad Co., 10 Bridge St., New York.	
SMITH, FRANK M.	Aug. 23, 1905
Engineering Department, N. Y., N. H. & H. R. R. Co., Danbury, Conn.	
SMITH, GEORGE E.	Feb. 10, 1903
Assistant City Engineer, Derby, Conn.	
SMITH, WILLIAM G.	April, 1884
Civil Engineer and Surveyor, Waterbury, Conn.	
SNELL, EDWARD B.	Feb. 13, 1906
Civil Engineer, New Haven, Conn.	
SNELL, HARRY B.	Jan. 8, 1901
Civil Engineer, New Haven, Conn.	

LIST OF MEMBERS.

173

SOEHRENS, JOHN H.	Aug. 10, 1904
Civil Engineer, N. Y., N. H. & H. R. R., New London, Conn.	
SPENCER, NORMAN C.	Jan. 8, 1901
Spencer & Washburn, Civil Engineers, Hartford, Conn.	
SPENCER, WALTER T.	Jan. 9, 1900
Division Engineer, N. Y., N. H. & H. R. R., New Haven, Conn.	
SPERRY, A. WILLIAM	Jan. 9, 1900
Civil Engineer and Surveyor, New Haven, Conn.	
STEARNS, ELMER W.	Oct. 11, 1902
Civil Engineer, Berlin, Conn.	
STERLING, JULIAN	Aug. 12, 1908
The Peck Bros. & Co., 2 West 94th St., New York.	
STERLING, PAUL	Oct. 11, 1902
Civil Engineer, N. Y., N. H. & H. R. R. Co., New Haven, Conn.	
STILES, EDGAR H.	Oct. 11, 1902
Civil Engineer, New Haven, Conn.	
STODDARD, RAYMOND FRENCH	Jan. 9, 1900
Civil Engineer, Bridgeport, Conn.	
STONE, EDWARD M.	July 18, 1899
Civil Engineer and Surveyor, Hartford, Conn.	
STORRS, HARRY W.	Aug. 23, 1905
Civil Engineer, Meriden, Conn.	
STORY, ISAAC M.	Feb. 13, 1906
Civil Engineer, N. Y., N. H. & H. R. R., New Haven, Conn.	
SULLIVAN, JOHN M.	Aug. 10, 1904
Civil Engineer, N. Y., N. H. & H. R. R., New Haven, Conn.	
TAYLOR, CHARLES F.	Aug. 12, 1908
Civil Engineer, Windsor, Conn.	
TAYLOR, EDWY L.	Feb. 13, 1906
Civil Engineer, N. Y. C. & H. R. R. R., New York.	
TAYLOR, LUCIAN A.	June, 1887
Civil Engineer and Contractor, Boston, Mass.	
TAYLOR, WILLIAM T.	Feb. 9, 1904
Civil Engineer, Hartford, Conn.	
TERRY, ALFRED H.	Feb. 11, 1900
Division Engineer, N. Y., N. H. & H. R. R., New Haven, Conn.	
THOMAS, JAMES B.	Jan. 9, 1900
Civil Engineer and Surveyor, Hartford, Conn.	
TONER, JAMES A.	Aug. 23, 1905
Civil Engineer, Meriden, Conn.	
TRACY, JOHN C.	Jan. 9, 1900
Assistant Professor of Structural Engineering, Yale University, New Haven, Conn.	
TRUESDELL, WALTER E.	June 11, 1898
Civil Engineer, 7 West 28th St., New York, N. Y.	
TRUMBULL, JOHN F.	Aug. 10, 1904
Civil Engineer, N. Y., N. H. & H. R. R., New Haven, Conn.	
TURNER, ALBERT M.	Aug. 10, 1905
Civil Engineer, Canaan White Lime Co., Canaan, Conn.	
UNKELBACH, MAX J.	Jan. 9, 1900
Architect and Civil Engineer, New Britain, Conn.	
VERRILL, GEORGE E.	Feb. 11, 1902
U. S. Assistant Engineer, New Haven, Conn.	

VORCE, CLARENCE B.	Jan. 10, 1899
Civil Engineer, 52 William St., New York City.	
WADHAMS, JOSEPH P.	Feb. 9, 1904
Civil Engineer, New Haven, Conn.	
WADSWORTH, A. R.	Oct. 27, 1886
Civil Engineer and Surveyor, Farmington, Conn.	
WARDWELL, FREDERICK S.	Feb. 9, 1904
Civil Engineer, Stamford, Conn.	
WASHBURN, ALBERT L.	Jan. 10, 1899
City Engineer's Office, Hartford, Conn.	
WATERMAN, CHARLES P.	Feb. 11, 1908
Civil Engineer, Bristol, Conn.	
WATSON, WILLIAM C.	Feb. 13, 1906
Engineering Department, N. Y., N. H. & H. R. R., New Haven, Conn.	
WEAVER, HALSEY A.	Jan. 12, 1897
Division Engineer, N. Y., N. H. & H. R. R., New Haven, Conn.	
WEBSTER, E. C.	Feb. 11, 1908
Civil Engineer, New Haven, Conn.	
WELTON, NELSON J.	April, 1884
Civil and Hydraulic Engineer, Waterbury, Conn.	
WHEELER, CHAS. A.	Jan. 8, 1901
Prof. of Mathematics, Conn. Agricultural College, Storrs, Conn.	
WHITE, HOWARD E.	Feb. 9, 1904
New Haven Gas Light Co., New Haven, Conn.	
WHITNEY, ELI	March 30, 1900
President New Haven Water Co., New Haven, Conn.	
WHITON, FRANK W., Associate Member	Feb. 14, 1905
Architect, Hartford, Conn.	
WIGGIN, ERNEST W.	March 30, 1900
Civil Engineer, C. C. O. R. R., Johnston, Tenn.	
WILCOX, RALPH M.	Jan. 8, 1901
Civil Engineer, Middletown, Conn.	
WILKES, J. K.	April, 1884
City Engineer, New Rochelle, N. Y.	
WILLIAMS, PHILIP K.	Aug. 14, 1906
Assistant Superintendent J. B. Williams Co., Glastonbury, Conn.	
WOLCOTT, HENRY A.	July 18, 1899
Mechanical and Civil Engineer, Hartford, Conn.	
WOOD, CHAS. N.	Aug. 14, 1900
Civil Engineer, Norwalk, Conn.	
WRIGHT, FRANK W.	Aug. 12, 1908
Card & Wright, Putnam, Conn.	

ALPHABETICAL LIST OF ADVERTISERS

Name	Business	Page
Aetna Life Insurance Co.	Insurance	37
Alpha Portland Cement Co.	Cement	2
Alsen's American Portland Cement Works	Cement	4
American Pipe and Construction Co.	Cast Iron Pipe and Contractors	3
Atlas Portland Cement Co., The	Cement	6
Balf Co., The Edward	Teaming and Contracting	45
Bausch & Lomb Optical Co.	Engineering Instruments	46
Beattie, John, The Est. of	Granite	43
Benvenue Granite Co.	Granite	23
Berger, C. L. & Sons	Engineering Instruments	38
Berlin Construction Co., The	Steel Structures	(back cover)
Blome Co., R. S.	Pavements	42
Buffalo Steam Roller Co.	Road Rollers, etc.	8
Chicago Bridge and Iron Works	Bridges and Tanks	31
Coldwell-Wilcox Co.	Valves and Machinery	28
Conard, William R.	Inspection Bureau	38
Connecticut Hassam Paving Co., The	Pavements	30
Connecticut Trap-Rock Quarries	Trap Rock	17
Consolidated Rosendale Cement Co., The	Rosendale Cement	(inside front cover)
Detroit Graphite Co.	Paint	48
Dixon Crucible Co., Joseph	Paint	10
Drouvé Co., The G.	Skylights	45
Eddy & Co., George M.	Tapes	13
Edison Portland Cement Co.	Cement	11
Edson Manufacturing Co.	Pumps	12
Engineering News, The	Magazine	34
Engineering Record, The	Magazine	22
French, Samuel H. & Co.	Cement	41
Grant, C. L.	Borings	26
Gurley, W. & L. E. Co., The	Engineering Instruments (inside back cover)	
Hammond, E. D.	Borings	22
Harrington, Robinson & Co.	Rails and Street Railway Supplies	44
Hartford Paving and Construction Co., The	Pavements	15
Hendricks Co., S. E.	Commercial Register	16
Hering & Fuller	Hydraulic and Sanitary Engineers	1
Hunt & Co., Robert W.	Inspecting	34
Iroquois Iron Works, The	Road Rollers, etc.	14
Keenan, D. F.	Crushed Stone	19
Keith, Herbert C.	Consulting Engineer	1
Kindling Machinery Co.	Street Cleaning Machines	7
Kingston Manufacturing Co.	Concrete Mixers	33
Kolesch & Co.	Engineering Instruments	41
Lathrop & Shea	Contractors	25
Lines Co., The H. Wales	Sewer Pipe, Stone and Cement	20
Lorain Steel Co., The	Rails and Street Railway Supplies	24
Lufkin Rule Co., The	Tapes and Rules	17
McKenna, Dr. Charles F.	Inspecting	41
National Paint Works	Paint	5
O'Brien Construction Co., The	Contractors	36
Pacific Flush Tank Co.	Miller Automatic Siphon	39
Rail Joint Co., The	Rail Joints	27
Riggs, G. G.	Contractor	47
Scherzer Rolling Lift Bridge Co., The	Lift Bridges	20
Scott Co., The T. A.	Marine Construction, etc.	32
Sessions Foundry Co., The	Sewer Castings, etc.	26
Soltmann, E. G.	Drawing Materials	41
St. Marys Sewer Pipe Co.	Vitrified Sewer Pipe	40
Standard Oil Co.	Road Oil	9
Stoddard-Brown Co., The	Engravers	38
Texas Co., The	Road Oil and Asphalt	5
Trinity College	Education	38
Tuttle, Morehouse & Taylor Co., The	Printers and Publishers	21
United Building Material Co.	Cement	18
Warner-Miller Co., The	Cement, Bluestone, Sewer Pipe, etc.	35
Warren Brothers Co.	Bitulithic Pavement	49
Warren Foundry & Machine Co.	Cast Iron Pipe	13

CLASSIFIED LIST OF ADVERTISERS

BLUE PRINTS.	
E. G. Soltmann, New York, N. Y.....	41
BORINGS.	
C. L. Grant, Hartford, Conn.....	26
E. D. Hammond, Hartford, Conn.....	22
BRICK.	
The Warner-Miller Co., New Haven, Conn.....	35
BRIDGES.	
Berlin Construction Co., Berlin, Conn.....	(back cover)
The Scherzer Rolling Lift Bridge Co., Chicago, Ill.....	29
Chicago Bridge and Iron Works, Chicago, Ill.....	31
CAST IRON PIPE.	
American Pipe and Construction Co., Philadelphia, Pa.....	3
Warren Foundry & Machine Co., Phillipsburg, N. J.....	13
CEMENT.	
The Atlas Portland Cement Co., New York, N. Y.....	6
Alpha Portland Cement Co., Boston, Mass.....	2
Aisen Portland Cement Co., New York, N. Y.....	4
Consolidated Rosendale Cement Co., New York, N. Y.....	(inside front cover)
The Warner-Miller Co., New Haven, Conn.....	35
The H. Wales Lines Co., Meriden, Conn.....	20
United Building Material Co., New York and Boston.....	18
Edison Portland Cement Co., New York, N. Y.....	11
Samuel H. French & Co., Philadelphia, Pa.....	41
CONCRETE.	
The Hartford Paving and Construction Co., Hartford, Conn.....	15
The O'Brien Construction Co., Waterbury, Conn.....	36
Lathrop & Shea, New Haven, Conn.....	25
CONCRETE MIXERS.	
Kingston Manufacturing Co., Wilkesbarre, Pa.....	33
CONSULTING ENGINEERS.	
Herbert C. Keith, New York, N. Y.....	1
Hering & Fuller, New York, N. Y.....	1
CONTRACTORS.	
The Hartford Paving and Construction Co., Hartford, Conn.....	15
American Pipe and Construction Co., Philadelphia, Pa.....	3
The Edward Balf Co., Hartford, Conn.....	45
The H. Wales Lines Co., Meriden, Conn.....	20
The O'Brien Construction Co., Waterbury, Conn.....	36
Lathrop & Shea, New Haven, Conn.....	25
G. G. Riggs, Waterbury, Conn.....	47
CRUSHED STONE.	
Connecticut Trap-Rock Quarries, New Haven, Conn.....	17
D. F. Keenan, Hartford, Conn.....	19
DRAWING MATERIALS.	
W. & L. E. Gurley, Troy, N. Y.....	(inside back cover)
E. G. Soltmann, New York, N. Y.....	41
EDUCATION.	
Trinity College, Hartford, Conn.....	38
ENGINEERS' AND SURVEYORS' INSTRUMENTS.	
C. L. Berger & Sons, Boston, Mass.....	38
George M. Eddy & Co., Brooklyn, N. Y.....	13
W. & L. E. Gurley, Troy, N. Y.....	(inside back cover)
Kolesch & Co., New York, N. Y.....	41
The Lufkin Rule Co., Saginaw, Mich.....	17
Bausch & Lomb Optical Co., Rochester, N. Y.....	46
ENGINEERING MAGAZINES.	
The Engineering News, New York, N. Y.....	34
The Engineering Record, New York, N. Y.....	22
ENGRAVING.	
The Stoddard-Brown Co., New Haven.....	38
EXPANDED METAL.	
The Warner-Miller Co., New Haven, Conn.....	35
FLUSH TANK.	
Pacific Flush Tank Co., Chicago, Ill.....	39
INSPECTING.	
Dr. Charles F. McKenna, New York, N. Y.....	41
William R. Conard, Burlington, N. J.....	38
Robert W. Hunt & Co., New York, N. Y.....	34
INSURANCE.	
Aetna Life Insurance Co., Hartford, Conn.....	37

IRON, STEEL, ETC.	
Berlin Construction Company, Berlin, Conn.	(back cover)
Chicago Bridge and Iron Works, Chicago, Ill.	31
LIFT BRIDGES.	
The Scherzer Rolling Lift Bridge Co., Chicago, Ill.	29
MARINE CONSTRUCTION.	
The T. A. Scott Co., New London, Conn.	32
PAINT.	
Detroit Graphite Co., Boston, Mass.	48
Joseph Dixon Crucible Co., Jersey City, N. J.	10
National Paint Works, Williamsport, Pa.	5
PAVEMENTS.	
The Hartford Paving and Construction Co., Hartford, Conn.	15
The Connecticut Hassam Paving Co., New Haven, Conn.	30
Warren Bros. Co., Boston, Mass.	40
R. S. Blome Co., Chicago, Ill.	42
PILING.	
The H. Wales Lines Co., Meriden, Conn.	20
The O'Brien Construction Co., Waterbury, Conn.	36
The T. A. Scott Co., New London, Conn.	32
Lathrop & Shea, New Haven, Conn.	25
PRINTERS.	
The Tuttle, Morehouse & Taylor Co., New Haven, Conn.	21
PUBLISHERS.	
S. E. Hendricks Co., New York, N. Y.	16
The Engineering News, New York, N. Y.	34
The Engineering Record, New York, N. Y.	22
PUMPS.	
Edson Manufacturing Co., Boston, Mass.	12
RAILS.	
Harrington, Robinson & Co., Boston, Mass.	44
The Lorain Steel Co., Johnstown, Pa.	24
RAIL JOINTS.	
The Rail Joint Co., New York, N. Y.	27
ROAD OILS AND ASPHALT.	
Standard Oil Co., New York, N. Y.	9
The Texas Co., New York, N. Y.	5
ROAD ROLLERS.	
Buffalo Steam Roller Co., Buffalo, N. Y.	8
The Iroquois Iron Works, Buffalo, N. Y.	14
SANITARY ENGINEERS.	
Rudolph Hering and George W. Fuller, New York, N. Y.	1
SEWER CASTINGS.	
The Sessions Foundry Co., Bristol, Conn.	26
SEWER PIPE.	
St. Marys Sewer Pipe Co., St. Marys, Pa.	40
The H. Wales Lines Co., Meriden, Conn.	20
The Warner-Miller Co., New Haven, Conn.	35
SKYLIGHTS.	
The G. Drouvé Co., Bridgeport, Conn.	45
STONE.	
Benvenue Granite Co., New York, N. Y.	23
The Estate of John Beattie, Leete Island, Conn.	43
Connecticut Trap-Rock Quarries, New Haven, Conn.	17
The Warner-Miller Co., New Haven, Conn.	35
D. F. Keenan, Hartford, Conn.	19
The H. Wales Lines Co., Meriden, Conn.	20
STREET CLEANING MACHINES.	
Kindling Machinery Co., Milwaukee, Wis.	7
STREET RAILWAY SUPPLIES.	
Harrington, Robinson & Co., Boston, Mass.	44
The Lorain Steel Co., Johnstown, Pa.	24
TANKS.	
Chicago Bridge and Iron Works, Chicago, Ill.	31
TAPES.	
C. L. Berger & Sons, Boston, Mass.	38
George M. Eddy & Co., Brooklyn, N. Y.	13
W. & L. E. Gurley, Troy, N. Y.	(inside back cover)
Kolesch & Co., New York, N. Y.	41
E. G. Soltmann, New York, N. Y.	41
The Lufkin Rule Co., Saginaw, Mich.	17
VALVES AND HYDRANTS.	
Coldwell-Wilcox Co., Newburgh, N. Y.	28
WELLS.	
E. D. Hammond, Hartford, Conn.	22

THESE Proceedings reach some 2500 engineers and contractors throughout the country. No like publication that we know of provides the same amount of advertising for so small an expenditure.

For rates and space, address

J. FREDERICK JACKSON,

Secretary, New Haven, Conn

DO NOT FORGET OUR ADVERTISERS

THEY ARE ALL FIRST CLASS AND RELIABLE

PATRONIZE THOSE WHO PATRONIZE US

Please Mention this Publication in Addressing Them

HERBERT C. KEITH

(MEM. AM. SOC. C. E.)

116 NASSAU STREET, NEW YORK

DESIGN AND CONSTRUCTION OF

Bridge and Structural Work

Masonry and Foundations

Railroads and Street Railways

Inspection and Valuation of Existing Structures. Legal Engineering.

Rudolph Hering

George W. Fuller

George A. Johnson

Elmer G. Manahan

HERING & FULLER

Hydraulic Engineers and Sanitary Experts

SPECIALTIES

WATER SUPPLY

SEWERAGE

WATER PURIFICATION

SEWAGE DISPOSAL

REFUSE DISPOSAL

170 BROADWAY

NEW YORK

Alpha Portland Cement

**THE RECOGNIZED
STANDARD
AMERICAN BRAND**

Alpha Portland Cement Co.

NEW ENGLAND DEPARTMENT

**521 and 522 Board of Trade Building
BOSTON, MASS.**

F. N. KINNEY, Manager

JOSEPH B. KEEN JR.
President and General Manager

H. BAYARD HODGE
Secretary and Asst. Treasurer

GEORGE M. BUNTING
Vice President and Treasurer

WM. H. BOTE
Assistant Secretary

American Pipe and Construction Company

Engineers and Contractors

No. 112 NORTH BROAD ST.

PHILADELPHIA

J. W. LEDOUX, M. AM. SOC. C. E.
Civil Engineer

JAMES H. DAWES
Supt. of Construction

HAROLD PEROT KEEN
Supt. Operating Dept.

AMERICAN AND GERMAN

FACTS ARE BETTER THAN ASSERTIONS

THE OLDEST MANUFACTURERS OF HIGH
PORTLAND IN THE WORLD. EXTRA QUALITY

ALSEN

AMERICAN 45 BROAD

THE SIDEWALK CEMENT

EVERY barrel of **ALSEN'S** guaranteed unreservedly to conform to "Standard" and Government Specifications. A medium slow set cement has proven in practical tests, in all countries, most **durable** and **safe**.

Forced strength, like forced growth, is **dangerous** to ultimate results.

We supply QUICK SET for special work only.

ALSEN'S is the **SAFEST** cement, as **Analyses** prove. So low in magnesia and sulphuric anhydride that Engineers and Architects give it preference in steel or hydraulic construction. We guarantee an Analysis that other large companies cannot meet.

The **Panama Canal Award** by Isthmian Commission, the 70,000 bbl. City of Rochester contract, the 100,000 bbl. New Orleans Filtration Plant, the 200,000 bbl. Key West Extension, and many works of nearly equal importance, without a single rejection under most rigid tests, substantiate every assertion made for this Portland. Alsen's was also selected for the 1,100,000 bbl. **Ashokan Dam contract**.

"CEMENT INSURANCE"

NATIONAL PAINT WORKS

Established 1876

WILLIAMSPORT, PA.

Railroad and Technical Paints

*Specialists in
Paints for Metal Surfaces*

*Our Paints are on more bridges than all other
makes combined*

Send to our Main Sales Office, at 100 William Street, New York City,
for a free copy of the Seventh Edition of the Review of Technical
Paints for Metal.

For Bituminous Macadam Work

TEXACO

**Liquid Asphalt
Macadam Binder
Road Asphalt**

CONTAIN ONLY VALUABLE BINDER

Have proved themselves a practical success

Used by the Rhode Island State Highway Commission

THE TEXAS COMPANY

**New York, Philadelphia, Providence, St. Louis, New Orleans
Houston Dallas, Port Arthur and El Paso, Texas**

The Standard American Brand

ALWAYS UNIFORM



NONE JUST AS GOOD

The Cement bought by the U. S. Government for the
Panama Canal,—4,500,000 barrels

**LARGEST CAPACITY OF ANY CEMENT COMPANY IN
THE WORLD, OVER 40,000 BARRELS PER DAY**

THE ATLAS PORTLAND CEMENT CO.

30 Broad Street, New York City

Send for our books on concrete construction

A RUBBER SQUEEGEE CLEANER

that replaces the Sprinkler, Sweeper and Scraper,
and cleans a street as a rubber squeegee does a window

What some City Officials think of the Kindling Street Washing Machine

"I consider it the most practicable street cleaner for smooth pavement that I have ever seen. Its advantages over other flushing machines are that its sprinklers are under no heavy air pressure, so detrimental in my opinion to asphalt and other similar pavements, and at the same time there is practically no waste of water, as it is about all used by the heavy revolving rubber squeegee which washes the pavement so thoroughly as to leave no slime, mud or dust."—CHARLES J. POETSCH, City Engineer, Milwaukee, March 20, 1908.

"I am in receipt of your communication of August 10th, enclosing bill of lading for three (3) of your Street Washing Machines, which completes the order for ten (10) machines for this

department. These machines are doing most excellent work, both in point of thoroughness and economy. We are making an extensive test with the machines, covering the street area cleaned, quantity of water consumed and cost of operation. When sufficient data is obtained I shall be glad to let you have a statement of the results."—FOSTER CROWELL, Commissioner of Street Cleaning, New York, August 18, 1908.

"I am pleased to give you the data procured by our test mentioned in my letter of August 18. We cleared 37,814 sq. yards in one day with one machine, and with a consumption of 143 gallons of water per 1,000 sq. yards, cleaned once."—FOSTER CROWELL, New York, December 23, 1908.



KINDLING MACHINERY CO.
MILWAUKEE, WISCONSIN

LET US SEND COMPLETE DESCRIPTION

BUFFALO PITTS



Double Drive Tandem Roller

Tandem Rollers
Asphalt Rollers
Golf Rollers

Macadam Rollers
Combination
Rollers
Road Scarifiers
Etc., Etc.



Double Cylinder Macadam Roller

WRITE FOR CATALOG

BUFFALO STEAM ROLLER COMPANY
BUFFALO, N. Y.

EASTERN OFFICES

150 NASSAU STREET, NEW YORK CITY
15 COURT SQUARE :: BOSTON, MASS.

STANDARD

Asphalt Road Oil Emulsifying Road Oil Macadam Asphalt Binder

For Allaying the Dust Preserving the Surface and Binding the Road

Experience and experiment have demonstrated that asphalt or oil with an asphaltum base are the only substances successfully applied to roads to insure permanency of dust relief and to maintain the roads in perfect condition.

In our three preparations we offer products that are suitable for road construction or road maintenance. Adapted for all conditions of roads and for use in all localities.

Full information on request.

STANDARD OIL COMPANY, Road Oil Dept.,

26 Broadway, New York.

115 Adams Street, Chicago, Ill.

Kansas City, Kan.

TWO OF THE
MANY RAILROAD
BRIDGES IN
NEW ENGLAND
WHICH ARE
WELL
PROTECTED
WITH



BANGOR & AROOSTOOK R. R. BRIDGE

Dixon's Silica-Graphite Paint

MADE BY

JOSEPH DIXON CRUCIBLE CO.



FALL RIVER VIADUCT, N. Y., N. H. & H. R. R.

Main Office
JERSEY CITY, N. J.

Boston Office
636 JOHN HANCOCK BLDG.

*Write our Boston Office
for
Colors and Specifications*

TO

"EDISON'S" 5 STRONG POINTS

Fineness
Color
Uniformity
Soundness
Sand Carrying
Capacity

TRADE MARK
Thomas A. Edison



There is no Cement on the market with more points in its favor than

EDISON PORTLAND CEMENT

The Anchorage of the Manhattan Suspension Bridge, the Bridge Loop connecting Brooklyn and Williamsburg Bridges, New Brooklyn Dry Dock No. 4, Bronx Storm Relief Tunnel Sewer, New York City; U. S. Navy Yard, Portsmouth, N. H.; Filtration Plants, McKeesport, Pa., and Philadelphia, Pa.; Sea Wall, North River, N. Y.; Windom Reservoir, Orchard Park, N. Y.; Dam and Power House, Great Falls Sta., S. C.; Dam and Power House, Rocky Creek, S. C., are a few of the many construction works of importance into which "Edison" is going.

85 per cent. through 200

98 per cent. through 100

Every Barrel of "Edison" Guaranteed to Pass Standard Specifications

Edison Portland Cement Company

SALES OFFICES

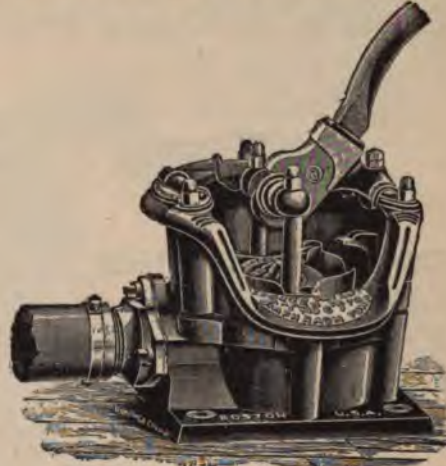
New York, St. James Building
Philadelphia, Arcade Building
Pittsburgh, Machesney Building

Boston, P. O. Square Building
Newark, N. J., Union Building
Savannah, National Bank Building

PUMP MAKERS FOR 50 YEARS



Lift and Force Pump,
Nos. 8 and 10



Trench Pump, Nos. 2, 3 and 4

EDSON PUMPS

Edson Diaphragm Pumps are used all over the world for raising large quantities of water full of gravel, sewage, etc., by hand power.

The Trench Pumps are in use by fully twenty-five per cent. of the railroads and water works in the United States, and by a large proportion of the excavating contractors. This is an open discharge pump, made in three sizes.

The Lift and Force Pumps, also made in three sizes, used by prospectors and miners, for deep trench work, odorless excavating, pile sinking, and for forcing cement into quicksands, are well worthy of your consideration.

Edson Pumps are portable and non-chokable, pumping anything liquid enough to flow.

Send for booklets telling what they have done for others.

EDSON MANUFACTURING CO.

250 Atlantic Avenue, - Boston, Mass.

ESTABLISHED 1859

GEORGE M. EDDY & CO.

345 to 353 Classon Avenue, Brooklyn, N. Y.



**COTTON TAPES
LINEN TAPES
STEEL TAPES**

Pioneers of the Tape Manufacturing Business in America

And the only firm giving its whole time and entire attention to the
manufacturing of tape measures

Warren Foundry & Machine Co.

ESTABLISHED 1856

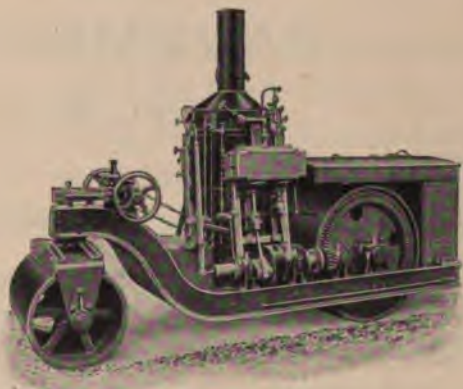
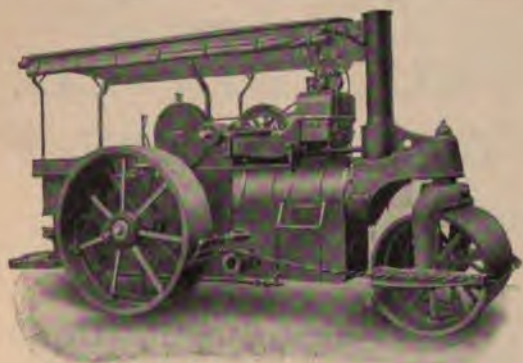
Works at Phillipsburg, New Jersey

Sales Office, 111 Broadway, New York

Cast Iron, Water and Gas	PIPE	From 3 to 60 in. in diameter
-----------------------------	-------------	---------------------------------

**Also all Sizes of Flanged Pipe
and Special Castings**

THE IROQUOIS IRON WORKS STEAM ROLLERS



THE AMERICAN STANDARD
FIFTEEN YEARS' EXPERIENCE
BUFFALO, N. Y.

THE
HARTFORD PAVING
and
CONSTRUCTION CO.

703 Main Street
Hartford, Connecticut

Concrete Arches *and* Foundations
PAVEMENTS

OF ALL KINDS

Artificial Stone Sidewalks
Masonry, Sewers

*Protect the Joints in your Concrete
with the*

HARTFORD WATERPROOF JOINT, patented
and insure good work

Established 1891

Issued Annually

Hendricks' Commercial Register

OF THE UNITED STATES

For **BUYERS** and **SELLERS**

Is the most complete work of its kind ever issued

Contains over 1300 pages. 350,000 names and addresses
listed under more than 28,000 classifications. . . .

PRICE, \$10.00, EXPRESS CHARGES PREPAID

Indispensable to purchasing agents for all large interests, including Machinery of all kinds, Mills, Mines, Railroads, Electric and Gas Lighting Companies, Municipalities, Governments, etc.

Each Classification represents the manufacturers or jobbers of some particular kind of machine, tool, apparatus, specialty or material.

Acknowledged by competent authorities to be the most complete and reliable Book of Reference for Buyer and Seller published.

The Popularity of Hendricks' Commercial Register is attested by the fact that more than 15,000 copies are now in use by the leading firms and corporations throughout the country.

S. E. HENDRICKS COMPANY, Publishers

74 LAFAYETTE STREET, NEW YORK

Connecticut Trap-Rock Quarries

INCORPORATED

CRUSHED TRAP-ROCK
FOR BALLAST, MACADAM, CON-
CRETE, WALKS, DRIVES, ETC.

OFFICE

46 MEADOW STREET, NEW HAVEN, CONNECTICUT
HOTEL GARDE BUILDING

Shipments by Rail to all points reached by The N. Y., N. H. & H. R. R. Co.

Daily Capacity of Crushers, 4000 Tons



LUFKIN

STEEL TAPES AND RULES
ARE INDISPENSABLE FOR ACCURATE WORK.

Made by **THE LUFKIN RULE CO.**

Saginaw, Mich., U. S. A.
New York. London, Eng.
Windsor, Canada.

FOR SALE EVERYWHERE.
SEND FOR CATALOG

Giant Portland and Union Rosendale Cements

Manufactured by American Cement Co. of Pennsylvania

Important Work on Which these Brands were Used

New York, New Haven & Hartford R. R.
New York Central & Hudson River Road.
Pennsylvania System and Weehawken &
Manhattan Shafts, together with North
and East River Tunnels, now under
construction.

Hudson Co.'s five tunnels under North River.
Atlantic Avenue Improvements, Brooklyn,
N. Y.

Brighton Beach Railroad Improvements,
Brooklyn, N. Y.

New Croton Dam and Aqueduct.

United Gas and Coke Co., Everett, Mass.

Boston Transit Commission, Boston, Mass.

Wachusett Dam, Clinton, Mass.

Jerome Park Reservoir, New York City.

Hall of Records, New York City.

Troop C, Armory, Brooklyn, N. Y.

Cross River Dam, Katonah, N. Y.

Re-Inforced Concrete Buildings

Automobile Co. of America, New York City,
7 story Garage.

Packard Motor Company, New York City,
6 story Garage.

Hodgman Rubber Co., Tuckahoe, N. Y.,
5 story Factory.

McNulty Company, New York City, 10 story
Warehouse.

Bowling Green Storage Co., New York City,
7 story Warehouse.

Wood Worsted Mills, Lawrence, Mass.,
7 story Warehouse.

Mergenthaler Linotype Co., Brooklyn, N. Y.,
8 story Factory.

Hanan Shoe Company, Brooklyn, N. Y.,
6 story Factory.

Schwarzchild & Sulzberger, New York City,
5 story Stable.

R. H. Long Shoe Co., Framingham, Mass.,
5 story Factory.

Commercial Trust Co., New York City,
6 story Bank and Office Building.

Boston & Albany Railroad, Boston, Mass.,
7 story Warehouse.

1,500,000 Bbls. of these brands used exclusively in construction by
Rapid Transit Subway Cons. Co. in New York
City and Brooklyn

United Building Material Company

320 Broadway, New York City

101 Milk St., Boston, Mass.

Quotations Sent Upon Application

D. F. KEENAN

Crushed Trap Rock

**For MACADAM, BALLAST
CONCRETE DRIVEWAYS
===== ETC. =====**

Rough Wall Stone and Bottom Stone Very Cheap

**Four Crushers at Work at Quarry near Newington
800 Tons Daily Capacity**

**Stone delivered by Electric Cars along all lines centering at Hartford
or dumped into carts at Bins rear of 173 State Street**

Telephone 1675

**OFFICE: ROOM 21, WAVERLY BUILDING
721 Main Street - HARTFORD, CONN.**

Represented by DON O'CONNOR

The H. Wales Lines Co.

MERIDEN, CONN.

DISTRIBUTOR OF

DEXTER PORTLAND CEMENT

Vitrified Salt-Glazed Sewer Pipe

A full line of all sizes and fittings in stock for prompt delivery

BLUE STONE

PILING

GRANITE

Builders' and Contractors' Material

Catalogue Printing

Quality

Should be the first consideration

Illustrations

Printed by experts—bringing out the *complete detail*—
assist greatly in *Making Sales*

Fine Catalogue Printing is one of Our Specialties

We represent The General Fireproofing Company in New
Haven and Southern Connecticut

FIREPROOF



Filing Devices

OFFICE FURNITURE

AGENTS FOR

Yawman & Erbe Manufacturing Company

Filing Equipment

Sectional and Solid

Supplies

Folders, Cards, Guides

The Tuttle, Morehouse & Taylor Co.

123 Temple Street

NEW HAVEN, CONN.

179 Crown Street

The Leading Civil Engineering Journal

OF AMERICA IS

THE ENGINEERING RECORD

During 1908 it published 2385 Proposal Advertisements calling for bids—more than appeared in any other engineering journal. THE ENGINEERING RECORD concentrates its attention exclusively on subjects of vital interest to the civil engineer. Its articles are written or revised by engineers connected with the works described.

SUBSCRIPTION PRICE BUT \$3.00 a year—less than six cents per copy.

SAMPLES ON REQUEST

THE ENGINEERING RECORD

239 West 39th Street, New York

E. D. HAMMOND

HARTFORD, CONN.

Foundation Borings Artesian Wells

WIND MILLS, ENGINES, TANKS AND TOWERS

Diamond Core Drilling

We remove uncertainty in foundation work by obtaining actual samples of all strata, whether same is sand, quicksand, gravel, clay, boulders or rock, etc.

Among others, we have made borings for—

U. S. Army Engineers, survey of Connecticut River and Providence River; Water Commissioners, Hartford, 4,100 lin. ft.; Bridge Commission, Hartford, 32 tests to bed rock; bridge, Derby, Conn.; Water Commissioners, Meriden, Conn.; Connecticut River Power Co., Brattleboro, Vt.; Tuttle Brick Co., Middletown, Conn.

BENVENUE GRANITE CO.

41 Park Row, New York, N. Y.

— — — — —
Granite—"Crotch Island" and "Sullivan" for
Building, Curb and Monumental Work
— — — — —

DESCRIPTION

"Crotch Island" Granite is light pink in color, which is perfectly uniform. It is a fine class of Granite and is suitable for every description of high-class building, monumental and curb work.

"Sullivan" Granite is of a light gray color, fine grained and uniform texture.

— — — — —
The Benvenue Granite Co. has quite recently installed at its quarries a complete outfit of Granite Cutting Machinery and accessories of the most modern description known to the Granite trade.

Our Motto is: Quick Deliveries

SEE OUR CURB ON THE NEW HARTFORD BRIDGE

The Lorain Steel Company

Girder Rails

High Tee Rails

High-Grade

Special Track Work

And Electrically Welded Joints

General Offices

Pennsylvania Building

Philadelphia, Pa.

Also Offices at

New York, N. Y., 30 Church St.
Pittsburg, Pa., Frick Building Annex
Atlanta, Ga., Equitable Building
San Francisco, Cal., Crocker Building

Chicago, Ill., Monadnock Block
St. Louis, Mo., Chemical Building
Cleveland, Ohio, Rockefeller Building
Philadelphia, Pa., Pennsylvania Building

JOHNSTOWN, PA.

LATHROP & SHEA

23 Church Street, New Haven, Conn.

General Contractors

STEAM SHOVEL WORK OF ALL KINDS

CONCRETE OF ALL KINDS

STEAM AND ELECTRIC RAILWAY
BUILDING

POWER PLANTS, DAMS, SEWERS,
ETC., ETC.

Test Borings==Exact Samples

CORE DRILL BORINGS FOUNDATION TESTS

FOUNDATIONS FOR HEAVY ENGINEERING STRUCTURES INVESTIGATED

Samples of all materials penetrated saved for record and inspection. Samples of sand, gravel, quicksand, clay, hardpan, etc., shown in same condition as it is from where it is taken.

CORE SAMPLE FROM ROCK

Samples from various strata of rock encountered for investigating the nature and extent of rock in new quarries, mines, etc. The actual stone is brought up for inspection.

**Artesian Wells, Windmills, Pumps, Drilling Machinery, Well Supplies,
Elevated Tanks for Sprinkler System of Fire Protection**

C. L. GRANT

58 Belden St., Hartford, Conn.

The Sessions Foundry Co.

BRISTOL, CONNECTICUT



**Low
Prices**

**Sewer and Subway Manhole Castings
Sewer Catch Basin Castings, etc.**

**To
Order**

Prompt Shipments

Write us for estimates

Delivery at any point

Over 50,000 Miles in use

Showing the unprecedented approval of the **Base Supported Rail Joint** by Railway Managers after fourteen (14) years' service



Weber Joint

MADE FROM
ROLLED STEEL
TO FIT OVER 145
SECTIONS OF
RAILS



Wolhaupter Joint

Received the
Highest
Awards

Paris, 1900

Buffalo, 1901

St. Louis, 1904



Continuous Joint



Continuous Girder Joint

Catalogs at Agencies

Baltimore, Md.	Pittsburg, Pa.
Boston, Mass.	Portland, Oregon
Chicago, Ill.	San Francisco, Cal.
Denver, Colo.	St. Louis, Mo.
New York, N.Y.	Troy, N. Y.

London, E. C., Eng. Montreal, Can.

The Rail Joint Company

GENERAL OFFICES:

29 West 34th Street, New York City

Makers of Base Supported Rail Joints for Standard and Special Rail Sections,
also Girder, Step or Compromise, Frog and Switch, and Insulating
Rail Joints, protected by Patents.

Sluice

Gates

ALL SIZES FOR ALL PURPOSES

Estimates and Specifications submitted for Hand, Hydraulic or
Electrically Operated Gates



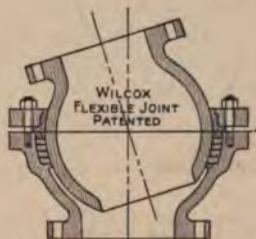
CIRCULAR GATE



RECTANGULAR GATE

Wilcox Patent Flexible Joints

Successfully Used on U. S. Government Hydraulic Dredges
and for Steam Purposes



Coldwell-Wilcox Company

NEWBURGH

NEW YORK

SCHERZER ROLLING LIFT BRIDGES

are Modern, Scientific, Safe, Simple, Efficient, and Economical and are superseding and replacing swing bridges and other old and obsolete types of movable bridges for Railroads, Electric Railways and Highways all over the World.



Scherzer Rolling Lift Bridge across West River at Kimberly Avenue, New Haven, Conn.

More than 120 swing bridges have already been condemned, removed and replaced by modern SCHERZER ROLLING LIFT BRIDGES for the following and many other Cities and Railroad Companies in the United States and Abroad:

Greater New York, Chicago, Boston, Cleveland, Buffalo, Peoria, Saginaw, New Haven, Gloucester, Manistee, Fall River, Cambridge, Bridgeport, Marseilles, St. Petersburg (Russia), Borough of Barrow-in-Furness (England).

N. Y., N. H. & H. R. R., N. Y. C. Lines, Penna. Lines, B. & O. R. R., L. S. & M. S. Ry., N. Y. C. & St. L. Ry., N. & W. Ry., S. A. L. Ry., Erie Railroad, M. W. S. E. R. R., Chicago; C. T. T. R. R., C. J. R. R., C. C. C. & St. L. R. R.; C. R. R. of N. J., B. R. B. & L. R. R., B. & S. R. R., C. L. S. & E. R. R., Can. Nor. Ry., N. & S. Ry., B. C. R. R., B. R. T. Ry., D. R. L. & W. R. R., G. & F. Ry., B. R. & P. Ry., S. E. & C. Ry., England; F. & R. Rys. Co., Ireland; Dutch R. R. Co., Holland; Furness Rys. Co., England; B. A. G. S. Ry., Argentina; Burma Rys., India; Tehautepec Ry. at Salina Cruz, Mexico; C. to C. R. R. at Port Soudan, Egypt.

Highest Award, World's Fair, St. Louis, 1904

Write us for Information, Photographs, Sketches and Estimates

THE SCHERZER ROLLING LIFT BRIDGE COMPANY

Main Offices: Monadnock Block, Chicago, U. S. A.

Cable Address

"SCHERZER, CHICAGO"

Eastern Office

220 BROADWAY, NEW YORK

The Leading Pavement

The following is an extract from the "Municipal Journal and Engineer," of March 4, 1908:

Relative Amounts of Various Pavements

"In New England we find eleven different kinds of paving, aside from macadam. Of these, stone block leads in quantity, and the others arrange themselves in the following order: gravel, brick, cobblestone, bitulithic, asphalt, Hassam, wood-block, asphaltine, asphalt block and bituminous macadam.

"Last year the largest amount of paving was stone block, followed by Hassam, gravel, brick, bitulithic and wood-block, in the order given."



HASSAM PAVEMENT ON OAK STREET, NEW HAVEN, CONN.

Laid by The Connecticut Hassam Paving Co.

Information and estimates for this most popular kind of pavement furnished on application to

The Connecticut Hassam Paving Company
902 Chapel Street, New Haven, Conn.

Metal Tanks

We are the builders of those hemispherical bottom elevated steel tanks which you have probably noticed in various parts of the country. We have done work of this character in 44 states and territories of the United States, in 6 of the provinces of Canada, in Mexico, Cuba, the Panama Canal Zone and the Philippine Islands.

The illustration shows a structure which we recently built for the Louisville Water Co., of



Louisville, Ky. This is the largest tank of its kind in the world, having a capacity of 1,200,000 gallons and a height of 220 feet from the top of foundations to the maximum water line of the tank.

We are prepared to design, manufacture and erect these tanks of any practical dimensions in any part of the world.

Our booklet, "Metal Structures," mailed upon request.

Chicago Bridge and Iron Works

105th and Throop Streets :: Chicago, Illinois

THE T. A. SCOTT CO.

Wrecking and Salvage Operations
of Every Character. Contractors
in Marine Construction. . . .

Steel, Concrete, Wood and Sheet Piling
Bridges, Cofferdams, Foundations
Marine Railways, Wharfs and Seawalls

DREDGING, TOWING
DIVERS AT SHORT NOTICE

NEW LONDON, - - - - - CONN.

Telephone 97-5, day or night

"THE HADSEL"



"THE MIXER THAT MIXES"

The Hadsel Concrete Mixer is built by an organization whose members have been in the concrete business for years.

It has won and maintains its preëminent position wholly on its merits. It is backed by the best guarantee ever given and by a company that is financially able to carry out every statement made in its behalf.

It was the first mixer to be built with cast iron drum, thus insuring greater wearing qualities as compared with steel plate for this class of work.

The driving mechanism is simplicity itself, all mechanical imperfections being avoided.

Not a piece of wood used in its construction, insuring absolute rigidity and alignment of all moving parts. DO NOT OVERLOOK THIS.

Get our catalog if you wish to find out how a concrete mixer should be constructed.

Capacity Simplicity Durability Rigidity

KINGSTON MANUFACTURING COMPANY

WILKESBARRE, PA.

Agencies in all of the Principal Cities

1874-1909

ENGINEERING NEWS

GEORGE H. FROST, President

**Thirty-five years of uninterrupted progress under the same
conservative management**

A journal of Civil, Mechanical, Mining and Electrical Engineering covering
a broad field in a most comprehensive manner from the standpoint of the highest
ideals of engineering and journalism.

One year, \$5.00; six months, \$2.50; ten weeks, \$1.00

A SPECIMEN COPY MAILED ON REQUEST

THE ENGINEERING NEWS PUBLISHING CO.

220 BROADWAY, NEW YORK CITY

ROBERT W. HUNT & CO.

ENGINEERS

TEST MATERIALS, INSPECT FABRICATION, SUPERVISE ERECTION

STRUCTURES OF EVERY DESCRIPTION

EXAMPLES:

BUILDINGS

Metropolitan Life Ins. Co. Bldgs.
Apthorpe Apartment Bldgs.
B. Altman "
Gorham Mfg. Co. "
Tiffany & Co. "
Singer Mfg. Co. "
Sixty Wall Street "

VAULTS

Sub Treasury, Wall Street
34th Street National Bank
Van Norden Trust Co.
Windsor Trust Co.
Liberty National Bank
Bankers Trust Co.
Seligman & Co., Bankers

REPRESENTATIVE BUILDINGS IN ALL THE LARGE CITIES
OF THE UNITED STATES

LABORATORIES

PHYSICAL, CHEMICAL, CEMENT

New York	Washington	Pittsburgh	Buenos Ayres	Chicago	San Francisco
Philadelphia	Montreal	New Orleans	London	St. Louis	Mexico City

RAILWAY, STEAMSHIP AND INDUSTRIAL PROPERTIES EXAMINED AND APPRAISED
ECONOMIC OPERATION DETERMINED

EXPANDED METAL

AND TWISTED STEEL RODS

FOR REINFORCING CONCRETE

ATLAS AND GIANT PORTLAND CEMENTS

SEWER PIPE



BLUESTONE

EXPANDED STEEL LATH

PAVING BRICK

**PROMPT DELIVERIES MADE FROM STOCK AT
NEW HAVEN**

The
O'Brien Construction Co.

General Contractors

36 North Main Street

Waterbury, Conn.

LIABILITY INSURANCE

THAT INSURES

The New Ætna Copyrighted Liability Policies mark the highest point of development yet reached in this form of insurance protection

ALL CLAIMS FOR DAMAGES

Are covered, regardless of whether or not the Insured is proved to be legally liable. They also cover claims for damages on account of injuries merely *alleged* to have been suffered

The value of their broad scope is enhanced by the most complete inspection service and the backing of the greatest assets of any company in the liability business.

ÆTNA LIFE INSURANCE CO.

ACCIDENT AND LIABILITY DEPT
HARTFORD, CONN.



C. L. BERGER & SONS,

37 William St., BOSTON, MASS.

SPECIALTIES:

Surveying Instruments of Precision.

ALL KINDS.

ALL SIZES.

Catalog on Application.

WILLIAM R. CONARD

(Assoc. Amer. Soc. C. E., Assoc. M. Amer. Soc. M. E.)

Inspection of Rails, Bridge Materials, Building Materials of Iron and Steel,
Cars, Locomotives, etc.

Specialty: Inspection of Pipe and Specials and all Water-Works Materials.

322 High Street - BURLINGTON, N. J.

Southern Office, Maison Blanche Building, New Orleans, La.

R. C. HUSTON, C.E., Representative

Department of Civil Engineering at Trinity College

In addition to the usual Collegiate Courses in
LITERATURE, SCIENCE, PHILOSOPHY, LANGUAGE,
ECONOMICS, AND HISTORY,

Trinity College now offers a full course in
preparation for the work of CIVIL ENGINEERING.

The Stoddard-Brown Co.

Engravers

66 CENTER STREET

NEW HAVEN, CONNECTICUT

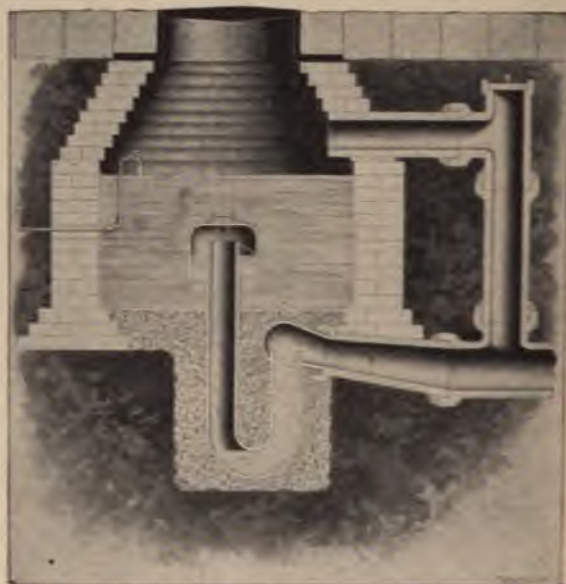
PACIFIC FLUSH TANK COMPANY

184 LA SALLE STREET, CHICAGO, ILL.

Manufacturers of the

Miller Automatic Siphon

FOR INTERMITTENT FLUSH TANKS



Used for Flushing Street Sewers

No Moving Parts

No Joints

No Little Traps

*Received the Highest Award in its Class at the World's Columbian Exposition
for Simplicity of Construction, Effectiveness and Reliability*

NEW HAVEN, CONN., March 21st, 1909.

The sewage filtration plant for Springside Home, New Haven, is equipped with an eight-inch special Miller Siphon, and has worked satisfactorily since put into operation, September 23, 1899.

(Signed) H. J. KELLOGG, C. E.

Each Siphon Guaranteed Absolutely

Send for Illustrated Catalogue

FRANK OBERKIRCH, *President*

GEORGE C. SIMONS, *Sec'y and Treas.*



St. Marys Sewer Pipe Co.

Sewer Pipe, Flue Linings

and all other clay products

St. Marys, Pa.

Long Distance Telephone



UNEQUALLED IN QUALITY

DEXTER

PORTLAND CEMENT

THE HIGHEST STANDARD
ATTAINABLE

Sole Agents

SAMUEL H. FRENCH & CO.

Philadelphia

Used in the Most Important Engineering Work

TRADE MARK REGIST.
IN-KO-GRAF
U.S. PAT. OFFICE
PRINTS

BLACK LINES ON A PURE WHITE GROUND

SEND FOR CATALOGUE AND SAMPLE

Everything for DRAWING
All kinds of PRINTS

SOLTMANN 125 E. 42d Street
New York

CHEMICAL AND PHYSICAL LABORATORIES
—OF—

DR. CHAS. F. McKENNA

Office, HUDSON TERMINAL BUILDING

50 Church Street, New York City

BUREAU OF INSPECTION

Headquarters for Standard Tests of Materials, Specifications, Inspection and Control on great works, and for Expert Services in Chemical Engineering.

15 lbs. or 7 1-2 lbs.?



Why carry a heavy Transit when our "Pioneer" will answer your purpose for 90 per cent. of the work. Constructed on substantial lines and made for hard work. Our circular on "Pioneer" Transits tells you all. Write for one.

We also manufacture heavier grade of Transits and Levels.

KOLESCH & CO.

138 FULTON STREET

NEW YORK CITY

D²

Established 1885

GRANITOID PAVEMENT

(TRADE MARK REGISTERED)

The Superior of All Other Permanent Pavements



CHAPEL STREET, NEW HAVEN, CONN.

The Blome Company Patented Granitoid Concrete Blocked Pavement

A pavement of monolithic construction. Permanently retaining surface grades. Intended for all degrees of traffic. Satisfactorily withstands all climates. Becomes more durable with age. The most sanitary pavement on the market to-day. The most suitable for street car track spaces. The handsomest of them all. A revolution in permanent pavements.

The foregoing claims are convincingly demonstrated by the pavements (from one to six streets respectively) laid for the following cities and corporations:

Knoxville, Tenn.; New Orleans, La.; Vicksburg, Miss.; Palestine, Texas; New Haven, Conn.; Boston, Mass.; New Brunswick, N. J.; Kalamazoo, Mich.; Red Jacket (Calumet), Mich.; Hancock, Mich.; Laurium, Mich.; U. S. Steel Corporation, Gary, Ind.; Western Electric Co., Chicago, Ill.; Armour & Co., and other packers at Chicago stock yards, etc., etc.

To those interested we will be glad to furnish further details.

RUDOLPH S. BLOME COMPANY

Main Office, Unity Building, Chicago

NEW YORK
Metropolitan Life Bldg.

BIRMINGHAM, ALA.
First National Bank Bldg.

NEW ORLEANS
740 Union Street

PETER BEATTIE, Esq.

JOHN BEATTIE, Jr., Esq.

THE ESTATE OF JOHN BEATTIE GRANITE QUARRIES

AT LEETE ISLAND AND HOADLEY'S NECK

OFFICE AND WORKS, LEETE ISLAND, CONN.

**Are well equipped to furnish Plain or Dressed
Granite in Large Quantities, by rail or water
shipment. Among others, have supplied Granite
for following constructions:**

Piers, Connecticut River Stone Bridge.	-	Hartford, Conn.
Soldiers' and Sailors' Monument.	-	Riverside Drive, N. Y.
The New Third Avenue Bridge.	- -	130th St., N. Y. City
Pedestal, Statue of Liberty.	- - -	New York Harbor
General Anderson Monument.	- - -	Pittsburgh, Pa.
General Flower Monument.	- - -	New York City
N. Y., N. H. & H. R. R. C. Improvement.	-	Bridgeport, Conn.
Residences.	- - - - -	Newport, R. I.
New Plaza Hotel.	- - - - -	New York City
Breakwaters at Block Island, Duck Island, New Haven, Bridge-		

port, etc.

**FOUR VESSELS WITH STEAM POWER TO
HANDLE HEAVY MATERIAL**

WHARTON SPECIAL TRACK WORK

OF SUPERIOR DESIGNS
FOR ALL CLASSES OF SERVICE

MANGANESE
STEEL
TRACK WORK
IS OUR SPECIALTY

WM. WHARTON JR. & CO.

INCORPORATED

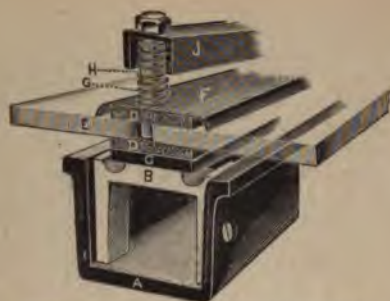
PHILADELPHIA, PA. - JENKINTOWN, PA.

NEW ENGLAND REPRESENTATIVES:

HARRINGTON, ROBINSON & CO.

272-276 FRANKLIN STREET - BOSTON, MASS.

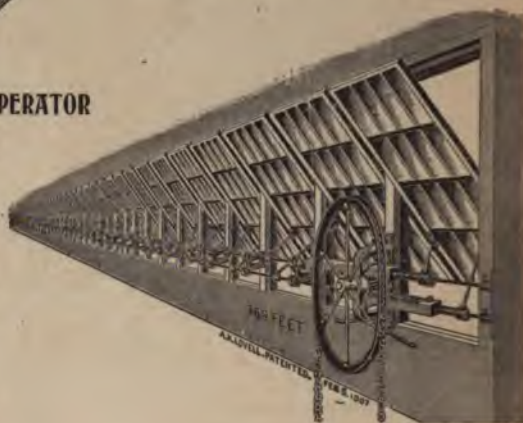
EVERYTHING FOR ELECTRIC RAILWAY TRACK CONSTRUCTION
STEEL BRIDGES - ROOF TRUSSES - STRUCTURAL STEEL



THE LOVELL WINDOW OPERATOR

By utilizing the straight push-and-pull principle, the Lovell Device works easily and quickly. From one station it will open or close 100 or more lineal feet of sash. We furnish estimates and guarantee satisfaction. Descriptive matter on request.

THE G. DROUVE CO.
Bridgeport, Conn.



ANTI PLUVIUS PUTTYLESS SKYLIGHTS

Impervious to rain, dust or weather. Each glass rests independently, and never touches metal or hard surface. 3,000,000 square feet now in use. Send for full particulars.

The Edward Balf Company

26 STATE STREET, HARTFORD, CONN.

GENERAL TRUCKMEN
AND CONTRACTORS

BUILDING STONE

CRUSHED STONE

SAND

GRADING

EXCAVATING



BAUSCH & LOMB TRANSITS AND LEVELS

are made under the personal supervision of George N. Saegmuller, formerly sole proprietor of Fauth & Co., Washington, D. C., and now a member of the Bausch & Lomb Optical Co.

The distinctive features of these instruments are the

- Large aperture and perfection of the optical parts
- Precise graduations
- Accurate levels graduated on the vial
- Extra long centers, insuring accuracy
- Continuous variation plates
- Hollow, elliptical compass needles
- Variable power eyepieces
- Excellent mechanical construction

DESCRIPTIVE CATALOG FREE UPON REQUEST



Our Name on a Photographic Lens, Microscope, Field Glass, Laboratory Apparatus, Engineering or any other Scientific Instrument is our Guarantee.

Bausch & Lomb Optical Co.

NEW YORK WASHINGTON CHICAGO SAN FRANCISCO
LONDON ROCHESTER, N.Y. FRANKFORT

G. G. RIGGS
Contracting Engineer



ROUND HOUSE AND MACHINE SHOPS
Meriden Junction, Waterbury, Conn.

Reinforced Concrete Structures

95 BANK STREET

WATERBURY

CONNECTICUT

WE WANT TO SEND YOU COPY OF OUR BOOKLET

**The best way
to prevent
RUST**

WHICH TELLS HOW AND WHY

“Superior Graphite Paint”

WILL DO IT

Immediate Shipments made from New York and Boston Stock

WE MAKE A FULL LINE OF COLORS

Our paint has been used on many bridges and buildings in
Connecticut to which we are glad to refer

DETROIT GRAPHITE COMPANY

PAINT MAKERS

135 Broadway, New York

1117 Tremont Bldg., Boston

The Truth About Street Paving

develops after the pavement has been laid and when it is too late to correct mistakes.

When BITULITHIC is laid no mistake is made. The truth about street paving is then so fully, clearly and convincingly demonstrated that there is no room for doubt as to the IDEAL ROADWAY.

Write to-day for complete information concerning the BITULITHIC PAVEMENT and learn why millions of square yards have been laid in scores of cities in preference to all other kinds of paving.

Warren Brothers Company

BOSTON, MASSACHUSETTS

REGISTERED TRADE MARKS

"Bitulithic," "Puritan," "Bitrock," "Bituminous Macadam," "Bitustone"

W. & L. E. GURLEY

TROY, N. Y.

Branch Factory, Manufacturers' Exchange Building, Seattle, Washington

Civil Engineers' and Surveyors' Instruments and Accessories

PHYSICAL AND SCIENTIFIC APPARATUS

STANDARD WEIGHTS AND MEASURES



Catalogues and detailed information on request

D. E. BRADLEY
President

GEORGE H. SAGE
Vice President

SEYMOUR N. ROBINSON
Treasurer

Berlin Construction Company

STEEL BUILDINGS, BRIDGES
AND STRUCTURAL WORK



OFFICE AND WORKS: BERLIN, CONN.

220 Broadway
NEW YORK

131 State Street
BOSTON, MASS.



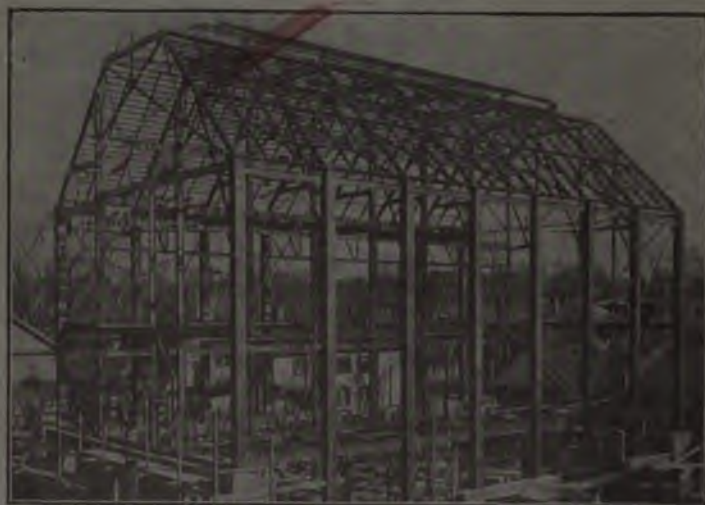
D. E. BRADLEY
President

GEORGE H. SAGE
Vice President

SEYMOUR N. ROBINSON
Treasurer

Berlin Construction Company

STEEL BUILDINGS, BRIDGES
AND STRUCTURAL WORK



OFFICE AND WORKS: BERLIN, CONN.

220 Broadway
NEW YORK

131 State Street
BOSTON, MASS.



J. J.

